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ALASKA REGION WATERSHED ANALYSIS TEAM REPORT

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Acronyms

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
BMP	Best Management Practice
CFS	Cubic Feet Per Second
CFSM	Cubic Feet Per Second Per Square Mile
CWA	Clean Water Act (1987)
DEM	Digital Elevation Model
EPA	U.S. Environmental Protection Agency
FEMAT	Forest Ecosystem Management Assessment Team
FHO	Fish Habitat Objective
GIS	Geographic Information System
LWD	Large Woody Debris
NEPA	National Environmental Policy Act of 1969
NFMA	National Forest Management Act and/or regulations of 1976
PACFISH	Strategy for restoring and protecting habitat of Pacific Salmon
RMA	Riparian Management Area
RSI	Riffle Stability Index
TE&S	Threatened, Endangered and Sensitive species
TLMP	Tongass Land Management Plan (as amended 1985-86)
TLMP-R	Tongass Land Management Plan Draft Revision (August 1991)
TTRA	Tongass Timber Reform Act
USGS	United States Geological Survey
USDA	United States Department of Agriculture

Terms

Area Team	Area Watershed Analysis Team
Regional Team	Regional Watershed Analysis Team

Regional Watershed Analysis Team

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*Because of the Federal Advisory Committee Act, non-Federal personnel were excluded from formulation of recommendations.

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Chapter 1

Introduction

Purpose

This report responds to concerns about the protection of fish habitat on the Tongass National Forest. *The Conference Report for the Fiscal Year 1994 Appropriations Act for Interior and Related Agencies* requires the Forest Service to “....proceed with stream analysis and studies and review procedures related to the PACFISH [strategy for restoring and protecting habitat of Pacific Salmon] strategy in 1994 in order to study the effectiveness of the current procedures such as buffer strips and to determine if any additional protection is needed....” on the Tongass National Forest. Therefore, there are two specific questions to be addressed:

- Are current fish habitat protection procedures effective?
- Is additional protection needed?

Senator Stevens’ letter to Regional Forester Mike Barton, dated November 17, 1993, reaffirmed the aforementioned questions: “The idea of the study is to collect further data to determine the effectiveness of TTRA [Tongass Timber Reform Act] buffers and site-specific buffer prescriptions.”

To answer the questions posed by Congress, the Alaska Region of the Forest Service and the Pacific Northwest Research Station are conducting an anadromous fish habitat assessment. An essential part of this assessment is to compare current management direction and practices with those recommended by Pacfish, which includes watershed analysis as a fundamental component. Therefore, the Alaska Region watershed analysis team (Regional team) was chartered to coordinate and help conduct one watershed analysis on each of the three Areas of the Tongass National Forest. The Regional team used *The Federal Agency Guide for Pilot Watershed Analysis* (Version 1.2, January 1994) for basic guidance.

This report documents the analytical process followed, evaluates techniques, and summarizes the findings of three individual watershed analysis reports. These findings are then displayed against the fish habitat protection measures put in place by the post-Tongass Timber Reform Act Records of Decision. These findings are provided to the fish habitat analysis team for use in responding to the two questions posed by Congress.

Considerable expertise and technology has focused on the interactions that exist between the watershed, the stream channel system, and fisheries habitat. This report along with the three watershed analysis reports represent the current watershed science, technology, and resources used to date to describe geomorphic processes, delineate sensitive riparian areas and hillslopes, and provide guidance for project-level planning.

Chronology of meetings and milestones

The Alaska Region has never prepared a watershed analysis. It has, however, provided considerable information for Version 1.2 of the *Federal Agency Guide for Pilot Watershed Analysis* [*Federal Guide*], January 1994. In reviewing the *Federal Guide*, it became clear that conducting a watershed analysis would be a major undertaking and would strain our resources.

The chronology of events throughout this period in preparation of the analysis covers the period October 14, 1993 through August 4, 1994. There was considerable interaction between the Regional team and the other teams charged with conducting the study and the Alaska Working Group on Cooperative Forestry /Fisheries Research. This chronology is presented in Appendix 1.

Chapter 2

Regional Watershed Analysis Process

Criteria for establishing watershed boundaries

After considering the capability and requirements of the GIS (geographic information system) database and the needs of the integrated resources inventory, the following criteria were established and applied for delineating watershed boundaries.

- A. Follow the guidance given in the *Federal Agency Guide for Pilot Watershed Analysis*. Generally, watersheds should range from 10 to 100 square miles in size.
- B. Utilize existing GIS watershed layer to aggregate upward to the watershed or watershed association level appropriate to address the issues and questions asked of the watershed analysis.
- C. Number watersheds and watershed associations using the existing National Forest System framework as described in Forest Service Manual 2513.1 and in conformity with the 1987 USGS Hydrologic Unit Map for Alaska.
- D. Determine watershed boundaries by utilizing hydrologic principles, and establish these boundaries along definable watershed divides. In karst terrain, adjust the boundaries to incorporate subsurface recharge areas identified.

Criteria for selecting pilot watersheds

The Regional team reviewed the Riverbasin assessment level issues summarized from input to the Tongass Land Management Plan Draft Revision and the Regional assessment level issues taken from Pacfish (Appendix 2). With the exception of the Pacfish issue relevant to identifying stocks potentially at risk, the Tongass Land Management Plan Revision issues cover all those identified. From these issues, the following key questions were identified:

- How do our management activities affect the hydrologic cycle?
- How do our management activities affect the sediment budget?
- How do our management activities affect the functions of wetlands?
- How do our management activities affect water quality?
- How do our management activities affect fish habitat?

Watershed selection criteria were drafted by the Regional team. Comments were received from the fish habitat analysis team and the Alaska Working Group on Cooperative Forestry/Fisheries Research. After discussion, the Regional team accepted the changes suggested by the fish habitat analysis team. The following list reflects the final watershed selection criteria.

Candidate (Area) watershed selection criteria

Primary (must have)

- Timber harvest in the watershed is covered by a Final Environmental Impact Statement and a signed Record of Decision.
- Timber harvest activity was/is being implemented with final layout and unit release cards reflecting Tongass Timber Reform Act requirements and guidelines (no appeal or litigation in progress or pending).
- Watershed is representative of other watersheds or of management units within the Area.
- Watershed has medium to highly diverse aquatic (fish) community structure.
- Watershed has a variety of channel types and medium to high habitat complexity.
- Watershed has had or will have high management intensity by Fiscal Year 94. This includes post-Tongass Timber Reform Act harvest (which is most important) but may also include past harvest and activities within the riparian areas.

Secondary (desirable)

- Data available
- Good access (road system in place)
- Moderate to high public interest

Additional Tongass-wide (Regional) selection criteria

Primary (must have)

- The three watersheds should be distributed across the range of natural variability on the Tongass, which includes watersheds conditions such as soil stability, mass-wasting potential, estuarine and wetland types, stream channel types, and habitat types.

Secondary (desirable)

- The three watersheds should represent the range of management activity, and techniques. At least one watershed will include historical management activity with a cumulatively moderate to high intensity.

Before the final watershed selection criteria were applied, the three criteria listed below were used to identify 48 potential candidate watersheds that are listed in Appendix 3. Each watershed had to

- 1) be covered by a post-Tongass Timber Reform Act Record of Decision or a pre-Tongass Timber Reform Act Record of Decision modified to meet Tongass Timber Reform Act requirements;
- 2) have a significant amount of Class I streams/habitat; and
- 3) be over 10 square miles in area.

After the watershed selection criteria were finalized, the Regional team reassessed the list of 48 potential candidate watersheds and selected 10 watersheds that passed the test of meeting all of the primary Area selection criteria (Appendix 3). These 10 candidate watersheds were then subjected to all of the selection criteria in order to select the three tentative pilot watersheds that best fit all criteria. In addition, the Regional team listed the attributes of each of the three tentative pilot watersheds and discussed the pros and cons of studying it both on its individual merit and in relation to the other pilot watersheds. The following pilot watersheds were selected:

Game Creek watershed	Chatham Area
Kadake Creek watershed	Stikine Area
Old Franks watershed	Ketchikan Area

Process followed in conducting pilot watershed analysis

During the initial meetings of the Regional and Area watershed analysis teams, members agreed that the best approach to accomplishing the analysis of the selected pilot watersheds (in the limited time available) was to utilize the *Federal Guide for Pilot Watershed Analysis*, version 1.2, January 1994, with modifications to fit the specific concerns unique to the coastal Alaska environment.

The Regional team developed a list of parameters (e.g., channel type, flow geology, etc.) that all Area teams must consider in their analyses in order to clearly identify watershed concerns and to assure uniform collection and reporting of data and observations relevant to the individual watersheds. It was understood that all parameters may not be applicable in every watershed; therefore, parameters must be considered, but they may be rejected at the discretion of the Area teams as long as a reasonable explanation is provided. These parameters, the current source of parameter data, and the protocols for collecting and analyzing these data are contained in Appendix 4.

Protocol guidance

Many of the modules in Part 2 of the *Federal Guide* were general in nature or undeveloped. It became clear when developing the parameter list that certain special protocols were needed to address the questions in Southeast Alaska. In particular, specific protocols were needed for:

Region 10 Watershed Analysis

1. Mass-movement hazard rating
2. Sediment transfer hazard rating
3. Channel type verification
4. Channel stability assessment using RSI and *Federal Guide*
5. Macroinvertebrate assessment
6. Classification and quantification of stream habitat using basinwide survey
7. Road conditions assessment

Individual members from both the Regional team and Area teams were assigned responsibility for developing these protocols. The protocols, procedures, and tools used in the watershed analyses are listed in Table 1.

Common objectives

The following common objectives were also established and agreed upon for the pilot watershed analyses to assist with comparisons across the Tongass National Forest. 1/

1. Identify important riparian areas within the watershed
2. Identify current conditions and trends in these riparian areas (in response to natural and management disturbance)
3. Review fish habitat objectives drafted by the fish habitat analysis team and refine the riparian management areas to meet the site-specific conditions within the individual pilot watersheds
4. Delineate the riparian management area within the individual pilot watersheds to attain and/or maintain the fish habitat objectives
5. Provide a means for comparing the site-specific application of the current procedures and the Pacfish management philosophy
6. Recommend watershed rehabilitation as appropriate
7. Recommend validation and baseline monitoring as appropriate

To address items 4) and 5), a common method was developed for the delineation of riparian management areas and displaying them in conjunction with post-Tongass Timber Reform Act activities.

1/ The terms riparian habitat management objectives (RHMOs) and riparian habitat conservation areas (RHCAs) may be encountered in the Area watershed analysis reports. These terms have identical meaning to the terms fish habitat objectives and riparian management areas as used in this report.

Table 1 - Protocols, Procedures, and GIS Coverages used in Watershed Analysis

Protocol or Procedure	Game Cr.	Kadake Cr.	Old Franks
Protocols			
Mass-movement Hazard	Y	Y	Y
Sediment Transfer Hazard	Y	Y	Y
Channel Type Verification	Y	Y	Y
Riffle Stability Index	Y	Y	Y
Macroinvertebrate Sampling	Y	Y	Y ^{2/}
Basinwide Survey	Y	Y	Y
Road Condition Survey	Y	Y	Y
Procedures			
Watershed Analysis Guidance	Y	Y	Y
Hillslope Traverse	Y	N	N
Riparian Area Verification	Y	N	N
USGS Flow Analysis	Y	Y	Y
FLOWMOD Calculations	Y	Y	N
Wetlands Survey	Y	N	N
Stream Habitat Mapping	N	Y	N
Fish Passage/Culvert Monitoring	Y	Y	Y
GIS RMA Delineation	Y	Y	Y
RMA Site Analysis	N	Y	N
Field Comparison RMA/TTRA	Y	Y	Y
GIS Coverages			
Digital Orthophoto	Y	N	N
Landforms	Y	N	Y
GIS Streams Layer	Y	Y	Y
GIS Soils Layer	Y	Y	Y
GIS Units Layer	Y	Y	Y
GIS Roads Layer	Y	Y	Y
GIS Geology	Y	Y	Y
GIS Watershed	Y	Y	Y
GIS Digital Elevation Model	Y	Y	N
GIS Vegetation	Y	Y	Y
GIS Landslides	N	Y	N
GIS Blowdown	Y	Y	N

^{2/} Laboratory report not yet received.

Region 10 Watershed Analysis

Chapter 3

Overview of Area Watershed Analysis Reports

Commonalities and differences

A. Databases

In general, the GIS databases were a valuable tool and performed well. However, some problems were encountered in the use of the GIS database on all three Areas.

Occasional inaccuracies exist between harvest unit locations and stream courses. This is due, in part, to the difficulty in locating small streams through the forest canopy, lack of ground verification of all elements, and timely updating of the GIS database. In addition, a finer digital elevation model grid would improve accuracy.

Game Creek Watershed (Chatham Area)

The Chatham Area used a digital orthophoto base map registered by field geographic positioning system points. This orthophoto was based on 1986-89 aerial photography. The Chatham Area's channel-type data layer was remapped and digitized. Channel types and stream classes were field verified. The common land unit layer was restratified for timber types and redigitized. The harvest unit and roads layer used was that existing in the Chatham Area GIS database library and was not updated and registered to the orthophoto. The Chatham Area also incorporated the wind pattern data developed for the Indian River/Kennel Creek Project Area.

Kadake Creek Watershed (Stikine Area)

The Stikine Area used the existing unregistered orthophoto base. The existing GIS watershed, channel type, stream class, soil type, vegetation, harvest unit, and road data layers were used (see Table 1). Field verification of some channel types and stream classes was completed and the database was updated. New layers were created to show landslides and blowdown.

Old Franks Watershed (Ketchikan Area)

The Ketchikan Area used the existing unregistered orthophoto base. The GIS channel type, landforms, soils, harvest unit, and roads data layers were also used (see Table 1). The harvest unit layer reflects actual final unit layout. After field verification was completed, the streams layer was remapped and the database updated.

B. Protocols

Game Creek Watershed (Chatham Area)

The Chatham Area applied the watershed analysis protocols and procedures as listed in Table 1. The Game Creek basinwide survey was not a full basin survey because of time constraints. In addition to established protocols, a random selection of Class I and II channel-type segments, weighted by the percent of total channel length in the watershed, was used to assess fish habitat character and stability. A comprehensive survey of habitat and morphologic features was completed for approximately 20 percent of the Class I and II stream channel segments. These channel segments were then habitat typed. The Chatham Area also used riparian zone and hillslope transects to verify riparian vegetation and hillslope landform characteristics. Vegetation plot samples were conducted on bogs and fens to verify wetland delineations.

Buffer blowdown surveys were conducted only on Forest Service lands by following the Regional buffer stability monitoring procedure. One mainstem stream channel segment located on Sealaska Corporation holdings was surveyed. Sealaska provided additional habitat survey data for lower Game Creek. The comparison of riparian management areas to post-Tongass Timber Reform Act harvest unit design was conducted through GIS application only. An interdisciplinary field review of harvest unit design options was not done.

Kadake Creek Watershed (Stikine Area)

The Stikine Area applied the protocols and procedures as listed in Table 1. The Pacific Northwest Research Station, Forestry Sciences Laboratory conducted a full basinwide survey of the mainstem of Kadake Creek and the south fork of Kadake Creek. Fifty percent of the tributaries to these channels was sampled. The west fork of Kadake Creek was not inventoried because of time constraints. The Stikine Area conducted an interdisciplinary field review of the riparian management area delineations on all seven of the harvested post-Tongass Timber Reform Act harvest units and two completed road segments in the Kadake Creek Watershed. The field review compared the application of riparian management area delineations to Tongass Timber Reform Act harvest unit layout.

Old Franks Watershed (Ketchikan Area)

The Ketchikan Area applied the watershed analysis protocols and procedures as listed in Table 1. The Ketchikan Area conducted an interdisciplinary field review of the upper watershed to assess post-Tongass Timber Reform Act activities and verify GIS and air photo interpretations. A road condition survey was also conducted. Basinwide habitat surveys were conducted by the Pacific Northwest Research Station, Juneau Forestry Sciences Laboratory in 1990. The 1991, 1992, and 1994 surveys, in 4.6 miles of the mainstem of upper Old Franks Creek (all Class I fish habitat), were conducted by the Craig Ranger District. These surveys were all conducted above the lakes and private land.

Approximately 1.25 miles of stream lies on private land below the lakes and flows to salt water. The only GIS information available for this Sealaska and Kasilco land was from timber sale maps. The post-Tongass Timber Reform Act comparison was made to a GIS-derived riparian management area on Forest Service lands.

C. Fish Habitat Objectives (FHOs)

Initially, the fish habitat objectives included measurements for pools per mile and pieces of large woody debris per mile. Both of these measurements had a large range of variation. All FP5 and MM2 channels in all three watersheds were below the 25th percentile. Also, the LC process group channels were slightly below the 25th percentile for number of pools per mile. However, if the pool area is compared to the total area, both the FP5 and LC channels exceed the 75th percentile. In other words, there are numerically few pools, but they are large, which may reflect the relatively large size of the FP5 and LC channels and their relatively high stream power.

After learning about this situation, the fish habitat analysis team reexamined the stream attributes data for undisturbed streams in Southeast Alaska. The fish habitat analysis team determined that percent pool area and pieces of large, woody debris (LWD) per 1000m² were more meaningful indicators than those expressed on a per-mile basis. The fish habitat objectives were then adjusted as displayed in Table 2.

Game Creek Watershed (Chatham Area)

When compared to the fish habitat objectives, most stream segments surveyed in Game Creek exhibited normal fish habitat conditions (see Table 2). Large woody debris (LWD) greatly exceed fish habitat objectives in all channels when calculated on a unit-area basis. The large amount of LWD recruitment in FP5 channels probably reflects a high rate of LWD input from blowdown.

Pool area in the FP5 channels is lower than the fish habitat objective guideline. This may be an indication of the aggrading nature of the wide, flat valley bottom channel. The MM1 channels follow a similar pattern to the FP5 channels. The pools in Game Creek may be more numerous but smaller in size than other systems as a result of LWD loading that greatly exceeds the 75th percentile.

All channel-types surveyed for width/depth ratios in Game Creek were near or below the 25th percentile, which indicates above average fish habitat conditions.

Kadake Creek Watershed (Stikine Area)

Most stream channel segments surveyed in Kadake Creek were above the 25th percentile, and many exceed the 75th percentile for the pieces of LWD and percent pool area fish habitat objectives. The major exceptions are FP5 and MM2 channels, which represent the bulk of the Class I fish habitat by total area. These channels are

well below the 25th percentile for pieces of LWD per 1000 square meters; however, they are also above the 75th percentile in percent pool area, indicating excellent fish habitat (see Table 2).

The width-depth ratios for the MM1, MM2, and FP5 channels are slightly above the median values. This appears reasonable when compared with the percent pool area and LWD habitat parameters. However, the FP3 and FP4 channels are way above the 75th percentile in width/depth ratio, indicating significant channel widening and aggradation, which is in direct contradiction with the percent pool area fish habitat objective and indicates poor fish habitat. This apparent contradiction should be investigated.

After talking with the leader of the survey crew, it appeared to the Regional team that when the average pool depth is only 35 cm and the average riffle is 15 cm, these are not hydrologically significant pools. This suggests that some of the pools might actually be glides. From the hydrologic standpoint, the protocol may not adequately consider the bankfull or other reference stage. We need to do further work to define exactly what these parameters represent.

Large woody debris lies in heavy concentrations at several sites along the FP5 channel of lower Kadake Creek. This is attributed to recent flood flows of 1988 and 1993. (The October 26, 1993 flood flow was calculated to exceed the 50-year recurrence interval in the lower reach of Kadake Creek.) Although 101 acres of riparian forest harvest has occurred along 7.6 miles of predominately small streams in the Kadake Creek watershed in the 1970s and 1980s, the energy of these small streams is insufficient to mobilize and deliver the larger pieces of LWD to the lower channel system.

The low levels of large woody debris scattered along the FP5 channel does not appear to be related to riparian timber harvest, since the riparian zones of the adjacent and larger upstream channels are generally intact. This particular FP5 channel is relatively uniform and smooth; it has no rock outcrops, tight turns, or other obstructions to catch and hold the LWD. These conditions suggest an active, unstable channel subjected to episodic flooding, which controls habitat condition and masks any evidence of current management disturbance. The low number of pieces of LWD in the MM2 channels may also be the result of high flood flows sweeping this material downstream and/or the removal of LWD sources by past timber harvest.

Old Franks Watershed (Ketchikan Area)

All stream segments surveyed within the Old Franks watershed exceeded the 25th percentiles for the fish habitat objectives on all the mainstem channel types surveyed (see Table 2). However, with the exception of the FP5 channels, the pieces of large wood were well below the median. On the other hand, with the exception of the MC channels (which were at the median), all channels were well above the 75th percentile for pool area. The FP4 and FP5 channels were near the median range for width-depth ratios, while the MM2 exceeded the 75th percentile, indicating the potential of significant aggradation. In summary, the percent pool area statistics look very good for the FP4 and FP5 channels which represent the majority of the mainstem. However, due to a lack of reported values in the tributary streams, it is difficult to determine the overall health of the fish habitat within the Old Franks watershed.

Table 2. Comparison of Habitat Parameters with Fish Habitat Objectives expressed in Percentiles^{3/}

Habitat Parameter	*Channel Type or Process Grp	Regional Percentiles			Wtrshed Value(Mi. Surveyed)			
		25	50	75	Game	Kadake	Old Franks	
Pieces LWD/1000m ²	LC&MC	6	15	22	20 (0.4)	11 (2.3)	8 (0.5)	
	FP3	10	32	54	96 (1.3)	30 (1.4)	-	-
	FP4	8	24	34	46 (1.5)	10 (3.3)	12 (1.3)	
	FP5	4	5	6	21 (2.8)	2 (7.7)	18 (2.1)	
	MM1	27	45	82	96 (0.4)	110 (2.0)	-	-
	MM2	33	35	44	42 (1.7)	26 (4.2)	-	-
Percent Pool Area	LC	8	20	27	39 -	64 (1.3)	62 (0.3)	
	MC	11	22	39	- -	29 (1.0)	22 (0.2)	
	FP3	20	53	76	45 (1.3)	75 (1.4)	-	-
	FP4	35	47	59	50 (1.5)	69 (3.3)	71 (1.3)	
	FP5	47	51	60	37 (2.8)	69 (7.7)	58 (2.1)	
	MM1	28	40	52	18 (0.4)	56 (2.0)	-	-
	MM2	2	22	39	33 (1.7)	39 (4.2)	-	-
Bankfull width/depth	FP3	8	13	18	11 (1.3)	48 (1.4)	-	-
	FP4	16	25	35	20 (1.5)	48 (3.3)	31 (1.3)	
	FP5	30	45	70	32 (2.8)	55 (5.5)	49 (2.1)	
	MM1	9	12	18	7 (0.4)	13 (2.0)	-	-
	MM2	17	24	33	15 (1.7)	28 (2.5)	-	-

^{3/} See Appendix 1 of the Fish Habitat Analysis Team Report for a complete discussion of the development and interpretation of the fish habitat objectives.

* Process group codes and descriptions are in *CT Users Guide* and Table 1-A of the fish habitat analysis team report. Alpha codes define the channel process group category while numeric codes define distinct channel types within each process group. Channel types are:

- FP3 - small floodplain channel
- FP4 - medium floodplain channel
- FP5 - large floodplain channel
- MM1 - small, moderate-gradient, unconstrained channel
- MM2 - medium, moderate-gradient, unconstrained channel

Four years of basinwide habitat survey information (1990-1992 and 1994) was summarized. As a result of differences in survey methods and time constraints, only total pool area and pool depth can be compared for 1990, 1992, and 1994. No trends or changes were evident.

Summary conclusions: The majority of the fish habitat objective parameters measured indicate conditions near the median fish habitat objective values. Based on the fish habitat objectives, there is no conclusive evidence to suggest any of the three watersheds have had their fish habitat degraded by management activities. There are, however, indications of instability in the Kadake Creek watershed. Also, there is insufficient data to draw any conclusion about the Old Franks Watershed.

The Regional team has reservations regarding the generation of the fish habitat objectives. These reservations are related to the small sample size on which some of the fish habitat objectives are based. There is also a lack of adequate baseline data and consistently collected data on fish habitat variables. This information is needed to definitively assess habitat conditions and provide recommendations to minimize the risk associated with management decisions.

Current conditions and trends of fish habitat objective-related parameters

A. Water quality (Macroinvertebrates)

The macroinvertebrate protocol requires five separate samples be collected with a Surber sampler for the macroinvertebrate analysis from each sampling station or site. In addition, water quality data was obtained for temperature, pH, electrical conductivity, alkalinity, and sulfates.

Game Creek Watershed (Chatham Area)

Macroinvertebrate and water quality data from 10 sample sites indicate high water quality.

Kadake Creek Watershed (Stikine Area)

Macroinvertebrate and water quality data from eight sample sites indicate high water quality.

All Kadake Watershed water quality values fell within the range of State water quality standards except one pH measurement collected in Subwatershed A66D. This watershed is basically pristine and contains only 20 acres of clearcut near the ridgeline. Southeast Alaska stream pH tends to be quite acidic (particularly in bogs) as a result of the acidic nature of most soils and forest vegetation. The pH values also reflect basin geology, which is predominantly volcanic in Subwatershed A66D. There is no limestone or basic metasedimentary rock to buffer the waters in the rest of the subwatershed, and it produced the lowest dissolved solids, lowest alkalinity, and highest sulphate values.

Old Franks Watershed (Ketchikan Area)

Water quality samples from five sample sites meet established State water quality standards. No results are available for macroinvertebrates.

Summary conclusions: Water quality in all three pilot watersheds is high, and no impairment is indicated. Trends are unknown, however, because of the lack of prior measurements. An additional 2 years of monitoring will be required to develop any reasonable measure of change.

B. Erosion and Sediment Delivery

Each Area assessed the sediment transfer hazard for their respective pilot watersheds using a sediment transfer protocol, which identifies sediment sources, mechanisms of transport, and potential to impact fish habitat. (See Sediment Transfer Hazard Protocol, Appendix 4.)

Game Creek Watershed (Chatham Area)

Based on this protocol, ten of thirteen subwatersheds were rated as moderate; the remaining three were low. The overall sediment transfer hazard for the watershed is moderate. While several small-scale landslides (<0.5 acre) have occurred in clearcut units in the upper part of the watershed, none have reached or entered Class I, Class II, or Class III streams. Sediment sources are moderate. The potential for sediment deposition in Class I and Class II channels is moderate.

Kadake Creek Watershed (Stikine Area)

Based on this protocol, 7 of 13 subwatersheds rate high or very high; 1 is low; 5 are moderate. The overall sediment transfer hazard for the watershed is high. A total of 57 landslides were recorded in the watershed, of which 30 were triggered by a rain-on-snow storm event in 1988. Ten or 18 percent of these landslides directly affected salmonoid habitat (see Landslides, p. 19). This, coupled with evidence of aggrading channel conditions, indicate generally unstable conditions with a high potential for sediment deposition in the Class I and Class II channels.

Old Franks Watershed (Ketchikan Area)

Based on this protocol, four of seven subwatersheds rate very high; two are low; one is moderate. The overall sediment transfer hazard for this watershed is moderate. Only a few landslides are identified in the watershed, and none reached Class I, Class II, or Class III channels directly. Sediment sources are low. The potential for sediment deposition in Class I and Class II channels is moderate.

Summary conclusions - Based on this protocol, only the Kadake watershed has a high sediment transfer hazard and a high potential for accelerated sediment deposition into Class I and Class II channels. This conclusion is supported by other evidence, including high numbers of landslides reaching streams, unstable soils in portions of the upper watershed, and measured aggrading conditions in the mainstem.

The sediment transfer hazard protocol, while insensitive to changes at lower hazard levels, provides a working tool for relative risk rating in watersheds displaying high levels of natural instability. This insensitivity is primarily the result of the lack of quantitative information on existing erosion conditions and channel flow dynamics. In particular, the sediment transfer hazard protocol fails to consider the location and size of landslides, recognize landslides less than half an acre in size, and other point-sources of sediment delivered to the stream channel system. The protocol also fails to account for the impact of major storms and flushing flows. Potentially, the soils and geology data within the GIS inventory could provide a more sensitive and realistic measure.

C. Fish passage

Criteria were established for upstream passage of juvenile salmon and steelhead. Conditions suitable for juvenile salmon, steelhead, and trout will also pass adult fish.

Game Creek Watershed (Chatham Area)

No fish passage concerns were noted in the road condition survey.

Kadake Creek Watershed (Stikine Area)

All culverts along approximately half the road system were surveyed. Fourteen culverts are on verified Class I streams. Two culverts along roads constructed before passage of the Tongass Timber Reform Act do not meet the criteria for juvenile fish passage. No culverts were installed on Class I streams along post-Tongass Timber Reform Act-constructed road segments.

Old Franks Watershed (Ketchikan Area)

No fish passage concerns were noted in the road condition survey.

Summary conclusions: No major obstructions to fish passage resulting from management activities were noted in any of the pilot watersheds. Only minor obstructions were identified in the Kadake watershed, primarily from the inability of two culverts on pre-Tongass Timber Reform Act road segments to pass juvenile salmon.

D. Fish species occurrence and population trends

Kadake and Game Creeks support natural runs of anadromous fish. Until the construction of two fish passes in 1992, only the lower section of Old Franks Lake Creek had anadromous fish runs. Most of the species occurring in Southeast Alaska are found in all three watersheds (Table 3).

Escapement of adult salmon to their natal streams can be influenced by many factors, including freshwater habitat conditions, severity of winter weather, harvest, and oceanic conditions. Escapement trends are useful in monitoring the overall condition of salmon stocks and, in the case of declining populations, alerting managers to the need for closer scrutiny of conditions affecting salmon populations. A better measure of freshwater habitat conditions is smolt production from the streams in question. However, smolt production is generally more difficult and expensive to estimate.

Table 3. Species Occurrence by Water Body

	<u>Kadake Creek</u>	<u>Game Creek</u>	<u>Old Franks Creek</u>
Coho salmon	XX	XX	Establishing
Chum salmon	XX	XX	Incidental
Pink salmon	XX	XX	XX
Sockeye salmon	---	Incidental	(Estab.-stocked)
Steelhead trout	XX	Incidental	XX
Cutthroat trout	XX	XX	XX
Dolly Varden char	XX	XX	XX
Sculpin	XX	XX	XX
Stickleback	----	XX	XX

Game Creek Watershed (Chatham Area)

Thirty-three years of escapement data indicate the following:

- Pink salmon - escapement is stable.
- Chum salmon - escapement declined over the last 15 years, compared to the 15 years prior.
- Coho salmon - no formal surveys exist, but Game Creek is considered to be important for coho production.

Kadake Creek Watershed (Stikine Area)

Fifty years of pink and chum salmon escapement data suggest:

- Pink salmon - escapement increased during the 1980s and early 1990s.
- Chum salmon - no discernible trend in escapement over the last 15 years.
- Coho salmon - no surveys exist, but Kadake Creek is considered to be important for coho production.

Old Franks Watershed (Ketchikan Area)

- Chum, coho, and pink salmon - 11 years of periodic survey data (for the lower stream only) indicates population numbers varied widely with no trends apparent. One year of post-fish pass (impedance tunnel data) in 1993 showed 380 adult coho.
- Cutthroat trout - five years of snorkel counts (1990-94) indicate peaks in 1992 and 1994 (highest) in the upper system. Snorkel dates vary and may be the primary factor influencing population counts.

Summary conclusions: Only Game Creek chum salmon demonstrate a declining trend. Stable populations of pink salmon in Game Creek and the decline of chum salmon in other watersheds (Halupka, unpublished) suggests the decline may be a result of influences on the population other than freshwater habitat.

Population information for both steelhead trout and cutthroat trout is sparse. Both species can be indicators of habitat change, but because of their lack of commercial value (although they both have significant value in sport fishing), they have been largely ignored by fisheries managers. Cutthroat trout population studies conducted on Old Franks Creek and steelhead redd counts for Kadake Creek have established baseline data. Monitoring of cutthroat trout in Old Franks Creek should continue. Additional studies in representative watersheds on the Tongass National Forest should focus on the relationship between both steelhead and cutthroat trout populations and their freshwater habitats.

E. Blowdown

Game Creek Watershed (Chatham Area)

The natural rate of windthrow in the Game Creek watershed is high because of its location on northeast Chichagof Island. This area is subjected to frequent south-east and northwest gales. An accelerated rate of blowdown appears to be occurring along harvest unit edges in productive timber areas. There is no apparent correlation between presence of wind damage in the watershed and soil-site factors or in orientation of the buffers and unit edges. Three of five traversed post-Tongass Timber Reform Act buffers in one subwatershed have significant blowdown. In addition, extensive additional blowdown in post-Tongass Timber Reform Act buffers in Game Creek is anticipated over the next 10 years. This expectation is based on historical evidence and the accelerated blowdown that has occurred in the 2 years since harvest.

Kadake Creek Watershed (Stikine Area)

Natural blowdown, resulting from strong southerly winds, is common in the Kadake Creek watershed. Two of eight sampled stream buffers had extensive blowdown ranging from 20 to 45 percent of the trees. These buffers were generally oriented perpendicular to the valley wind pattern. Three of the sampled buffers had some blowdown, with approximately 5 percent of the trees affected.

Old Franks Watershed (Ketchikan Area)

There is a low historic rate of blowdown in Old Franks Watershed. While recent blowdown is not extensive, most of what has occurred has been associated with the edges of the post-Tongass Timber Reform Act harvest units.

Summary conclusions: Blowdown is a common natural process in Southeast Alaska, and it is a major element of forest disturbance in both Game Creek and Kadake Creek as a result of frequent southeast and northwest gales associated with fall storms. Accelerated blowdown activity occurs along unit boundaries and along buffer edges in all three watersheds, but is excessive in the Game Creek and Kadake Creek watersheds.

F. Landslides

Game Creek Watershed (Chatham Area)

There is an area of unstable soils in the upper Game Creek watershed with active mass wasting associated with snow avalanches. Recent small-scale landslides less than 0.5 acre have occurred in harvest units and along road cuts in headwater basins. None of the identified landslides have reached or entered directly into Class I or Class II channels. It is anticipated that the mass-wasting activity associated with harvest units and road cuts will continue over the next decade until root strength rebuilds.

Kadake Creek Watershed (Stikine Area)

Fifty-seven landslides greater than 0.5 acre were inventoried in 1994. Approximately 30 (or 50 percent) occurred during a single rain-on-snow event on December 1, 1988. Approximately half of the landslide acreage occurred in one subwatershed with pyroclastic geology. This subwatershed (which has <1% harvest activity) represents 10 percent of the area of the Kadake Creek watershed, but it is the major sediment source for the lower reach of the watershed. Only 4 of the 57 landslides originated in clearcut units; the rest originated from old-growth areas. Forty (or about 70 percent) of these landslides reached streams, five reached Class I, five reached Class II, and the rest reached Class III channels. Many of these landslides have revegetated and no longer represent active sources of sediment to the stream channel system.

Old Franks Watershed (Ketchikan Area)

Five landslides have occurred within the watershed. Four occurred in subwatershed R2—three between 1951 and 1971 and one between 1971 and 1991. In October 1994, a storm-associated landslide occurred in subwatershed S2, within sale Unit 613-106. No direct impact to any stream was observed, but fine sediment could be entering the S2 watershed stream network from this most recent landslide.

Summary conclusions: Landslides are a common and natural source of sediment and large woody debris within Southeast Alaska watersheds. Since the 1988 storm, landslides appear to be the major source of sediment in the Kadake Creek watershed. A small number of these landslides are the direct result of management activity; however, most landslides are the result of a combination of naturally unstable terrain and major storm events.

G. Riffle Stability Index (RSI)

The riffle stability index (RSI) is an adaptation of a technique developed on the Idaho Panhandle National Forest to assess the degree of aggradation, degradation, and dynamic stability of gravel and cobble bed stream channels (Kappesser 1993). Its adaptation in the form of a protocol to assess the stability of a channel reach was performed by the Stikine Area (Wolanek 1994) and was applied and addressed on all three pilot watersheds.

Game Creek Watershed (Chatham Area)

Five stream reaches were sampled using the RSI protocol. The general conclusion is that the channel stability is currently fair to good, but many channel segments are sensitive to increases in sediment.

Kadake Creek Watershed (Stikine Area)

Eight stream reaches were sampled using the RSI protocol. The RSI values indicate the watershed is in a moderate stage of aggradation. Values range from 71 to 89 and may have been influenced by a 50-year recurrence interval flood that occurred on October 26, 1993.

Old Franks Watershed (Ketchikan Area)

Five stream reaches were sampled using the RSI protocol. The RSI values ranged from 77 to 100. These data suggest that three sites are undergoing a high rate of aggradation and two are undergoing moderate aggradation. Values may have been influenced by a 20-year recurrence interval flood that occurred on October 26, 1993.

Summary conclusions: All three pilot watersheds demonstrate moderate to high aggradation in channels, especially on the lower gradient reaches near tide water. All three watersheds may have been affected by recent storm flow events which might have influenced RSI values, especially on Kadake (50-year event) and Old Franks (20-year event). Therefore, the calculated RSIs may be responding to disturbances caused by major storm events but not indicative of the stability of the watershed over time.

This is the first time this method has been applied in Southeast Alaska. The relative differences in these values for each watershed are consistent with other indicators, but the aggradation indicated by the RSI values are too high. More

information and work is needed on this protocol. The RSI values being used were developed for Idaho Panhandle streams using the Rosgen Channel Classification system. A comparison of the aggradation ratings of the RSI with the channel condition module in the Federal Guide (pages 2-88 and 2-93) indicates that the RSI needs more calibration for depositional channel types in Southeast Alaska. The Alaska Region may need to fine-tune the rating scale of this method to assist interpretations when using the Alaska Region channel classification system.

Current Condition and Trend Summary

Watershed analyses have shown that there is no measurable fisheries habitat degradation in the three watersheds studied. In general, our current procedures, and in the case of Kadake Creek, activities dating back to the mid-1970s have not caused measurable impairment of fisheries habitat. However, concerns relevant to fish habitat protection have been identified in each of the three watersheds studied.

In the Kadake watershed, most logging activities have avoided the fens and potentially unstable soil areas. With the exception of the 101 acres of riparian harvest along mostly small streams in the 1970s and 1980, the LWD-dependent Class I and II streams have generally received adequate protection (see Kadake riparian management area (RHCA) map and Table 4). In the Kadake watershed, 6 percent of the post-Tongass Timber Reform Act harvest unit acreage is within the riparian management area. The Kadake watershed has approached the point where, over the last 20 years, some of the subwatersheds have had up to 28 percent of their basins clearcut. The Stikine Area team has raised concerns about the potential cumulative effects with this amount of harvest. This concern illustrates that there may be a lack of confidence in the present Tongass Land Management Plan Revision assumption that 35 percent of a watershed harvested in 15 years presents minimal risk. There is a need for the Forest Service to develop a Region-wide cumulative watershed effects methodology and test it on the Kadake and other selected watersheds within the Tongass National Forest.

Presently, there is inadequate information to predict the level of cumulative watershed effects risk. We can only state after the fact that the watershed is or is not exhibiting a cumulative watershed effect. It should be noted that Kadake Creek has been tested by a 50-year recurrence interval flood and does not show evidence of exceeding its cumulative effects threshold. However, it appears close to this threshold, given the risk of another storm with a magnitude greater than 50 years.

Only 5.3 percent of the upper Old Franks watershed has been clearcut (all post-Tongass Timber Reform Act); only 12 acres of the 540 acres of clearcut is within riparian areas. However, 52 percent of the unit acreage is within the riparian management area on potentially unstable soils (see Old Franks Creek riparian management area (RHCA) map and Table 4). One unit is completely within the riparian management area. The October 26, 1993 storm generated a 20-year flood and triggered a landslide in this unit. This landslide may be supplying fine sediment to the stream channel system.

Presently, there is insufficient field analysis within the watershed to definitively state what effect our management practices have had. However, given the percentage (52%) of activity within the riparian management area, adverse impacts to fish habitat could occur at a lower degree of activity than in the Kadake Creek watershed.

Most of the logging within the Game Creek watershed has been under current procedures. About 27 percent of the harvest unit acreage is within the riparian or the potentially unstable soil areas of the riparian management area (see Game Creek riparian management area (RHCA) map and Table 4). The Game Creek watershed displays near median fisheries habitat conditions for the percent pool area and bankfull width/depth ratio fish habitat objectives while the LWD fish habitat objective is well beyond the 75th percentile, indicating potentially excellent fish habitat. Some of this high LWD loading is attributed to the blowdown that has occurred on some units. In addition to blowdown, there are a large number of small landslides within the potentially unstable soils areas of some of the harvest units. Last year's storm events within the watershed did not exceed the average annual intensity. Over time, as root strength of the stumps decays in clearcuts on the potentially unstable soils, a large magnitude storm event may trigger debris flows that could potentially adversely impact fish habitat. Probably not enough acreage has been harvested to date to significantly impair fish habitat, but this watershed likely has a lower threshold for manifesting a cumulative watershed effect than does the Kadake Creek watershed.

Table 4. Riparian Management Area Delineations on post-TTRA Harvest Units

<u>Game Cr.</u> Unit #	Acres Harvested	Riparian Management Areas (RMA) Delineated Acres			Percent Within RMA
		Fens	Riparian	Sediment	
86	85	0	0	0	0
88	55	0	0	0	0
90	37	0	0	19	51
91	78	0	0	16	21
92	58	0	0	24	43
93	50	0	0	7	14
95	41	0	0	0	0
99	17	0	13	0	76
110	69	0	4	0	7
121	25	0	15	0	60
122	14	0	11	0	19
123	23	0	0	0	0
124	120	0	0	0	0
125	24	0	6	0	25
133	113	0	0	34	30
134	126	0	0	63	50
135	128	0	0	73	57
157	21	0	0	0	0
197	59	0	0	0	0
198	53	0	0	35	0
Total	1,196	0	49	271	27%

Kadake Cr.

402-16	25	0	0.2	0	1
421-37	71	0	1.7	0	2
421-38	87	0	8.2	0	9
421-40	27	0	0.3	0	1
421-41	59	0.3	4.3	0	
Total	269	0.3	14.7	0	6%

Old Franks

613-101	57.4	0	0	12.6	22
-102	36.5	0	0	28.0	77
-103	103.7	0	0	19.2	19
-104	43.3	0	0	11.6	27
-105	55.2	0	1.7	15.3	39
-106	108.7	0	0	108.7	100
-108	70.8	0	0	58.2	82
-109	63.2	0	0.7	22.8	37
Total	538.8	0	2.4	276.4	52%

Comparison of Riparian Habitat Conservation Strategy and Current Procedures

Game Creek Watershed (Chatham Area)

Application

Riparian management area delineations were derived from GIS applications. The following conclusions were drawn from buffer condition surveys of five harvest units all within the riparian area of one subwatershed, and landslide surveys of upslope harvest units. Buffer deterioration from windthrow has occurred and is expected to continue. Erosion has reduced soil productivity on some potentially unstable soils within timber harvest units, and this impact is also expected to continue. Little evidence of sediment delivery from the timber harvest units to streams exists, but this situation could change over time as root strength declines and landslide occurrence increases.

Prescriptions for riparian management areas would have been different from current management prescriptions. For example, the prescriptions would recommend: (1) where stand conditions allow, buffer zone feathering for maintenance of core riparian areas, (2) limitation of timber harvest on potentially unstable soils (MMI 3 and 4), and (3) minimization of road construction on potentially unstable soils.

Discussion

1. In delineating riparian management areas, critical resource concerns are identified more accurately (through ground reconnaissance and updated resource databases) than has been typical of post-Tongass Timber Reform Act timber sale planning. The delineation of the riparian management area for Game Creek shows that most, but not all of the critical resource concern areas were protected by current management procedures.
2. The delineation of a riparian management areas requires more complete and accurate databases on a watershed scale. For example, In Chapter 7 of the Game Creek Watershed Analysis, the riparian management areas are delineated and displayed with the productive forest lands. This focuses the concern for fish habitat in the Game Creek watershed and defines which areas need to be evaluated most carefully in the field when planning timber sales.
3. The riparian management areas as delineated by watershed analysis would focus the project interdisciplinary analysis in the field on the critical riparian and sediment source areas within proposed harvest units, and on proposed roads located across fens. Current road location practices do not presently address impacts to wetland function.
4. The riparian habitat conservation strategy requires that planning efforts evaluate the impacts of proposed management activity on functions and processes in areas critical to protecting fish habitat. Even though there was an awareness of the blowdown hazard in Game Creek, post-activity monitoring demonstrated the design of stream buffers was inadequate to prevent substantial blowdown in some cases.

The riparian habitat conservation strategy identifies the need for alternative silvicultural prescriptions to maintain stable riparian management areas, while current procedures only recommend that Class I and II buffers be windfirm. If blowdown risk had been fully evaluated in Game Creek, some of the buffers perpendicular to the prevailing southeast winds would have been feathered or a selective harvest prescription would have been used. The same case exists for the sediment source areas on the hillslope harvest units in southwest Game Creek, as portions of these units lie on mass-movement index 3 and mass-movement index 4 soil hazard classes.

Kadake Creek Watershed (Stikine Area)

Application

The riparian management area delineations were first derived from existing GIS layers and aerial photo interpretation. The Stikine Area team followed up with an interdisciplinary field review of riparian management area delineations (site analysis) and compared the final riparian management area to the existing layout of the seven harvested post-Tongass Timber Reform Act harvest units and two completed road segments. The Stikine Area team concluded that minor adjustments of post-Tongass Timber Reform Act units would have resulted from the riparian habitat conservation strategy. Specifically:

Unit 402-16 would require more consideration for preventing the blowdown of the buffer on a Class 2 stream which is perpendicular to the prevailing wind pattern. The buffer would have been wider and tapered to avoid an abrupt windward face, with potential feathering, or the unit would have been eliminated.

Unit 421-46 has a very small Class II stream (2 ft. to 3 ft., bankfull width) that would have received no stream buffer after site analysis under the riparian habitat conservation strategy instead of the mandatory 100-foot buffer on both sides under current procedures. Split-yarding would have been prescribed. The buffer is not necessary because the channel is not wood-debris dependent. Split-yarding would have provided needed protection of channel side-slopes and eliminated downstream sediment concerns.

Discussion

If the Riparian Habitat Conservation Strategy had been available for use during the original planning, few differences in harvest unit and road design would have occurred from current procedures. Exceptions include:

1. The minimum 100-foot buffers may not have been required on several small Class II streams. Interdisciplinary field investigations determined that these channels are not large woody debris dependent and therefore, the only concern is bank stability and sediment delivery to downstream Class I habitat. Windthrow within the buffers may cause more sediment than would result from falling the trees and using the stream as a split line.

2. This comparison also shows the need for field verification of the GIS inventories and for applying site-specific prescriptions. Some locations of smaller streams and soil concerns were not correctly identified on the planning unit cards included in the EIS. These streams and concerns were identified later during unit layout, and appropriate protection measures were incorporated after the Record of Decision. Delineation of the riparian management areas and site analysis would have improved the unit planning and streamlined the layout.

Old Franks Watershed (Ketchikan Area)

Application

Riparian management area delineations were derived from GIS. No interdisciplinary field review (site analysis) of the riparian management area was conducted.

Comparisons were based on results of: (1) 1993 Best Management Practices (BMP) monitoring of five of the eight harvest units in the watershed; (2) the 1994 condition surveys of roads in the riparian management areas; and (3) the 1994 field visits to all post-Tongass Timber Reform Act harvest units by personnel collecting current condition data. Roads located on potentially unstable soils (mass-movement index 3) exhibit erosion of cutslopes, with sediment entering the stream network. Blowdown is occurring in association with harvest unit edges. A portion of every post-Tongass Timber Reform Act harvest unit lies within the GIS delineated riparian management area. One unit, 613-106, is completely within the riparian management area (mass-movement index 3 soils). This indicates that the riparian management areas would have potentially resulted in the modification of unit layout and timber harvest prescriptions, thus providing decreased risk of impairment of fish habitat by increasing protection for potentially unstable soils.

Discussion

1. The sale planning team (long-term sale) and District staff would have to function at a high level of communication and coordination to fully implement a riparian habitat conservation strategy, especially to implement ground based prescriptions within the riparian management area. Specifically, there would need to be full interdisciplinary team field reviews, and updating and use of the GIS data bases.
2. If the riparian habitat conservation strategy had been available for use during the planning of the post-Tongass Timber Reform Act harvest units, some of the harvest units would have been laid out differently. The greatest amount of change would have occurred in Unit 613-106 and in subbasin S2. In addition, the strategy would have modified road location and timber harvest prescriptions on potentially unstable soils (mass-movement index 3), and leave tree requirements along Class III streams. Also the decisionmaker would have been supplied with better information with which to assess risks of impairment to fish habitat.

Summary: The three pilot watershed analyses indicate that in comparison to current management procedures, the riparian habitat conservation strategy provides additional fish habitat protection in the following ways:

1. The riparian habitat conservation strategy provides for more scrutiny and emphasis on riparian-dependent resources and stream processes, especially regarding resource protection needs adjacent to Class III streams.
2. Riparian management area delineation more clearly and completely identifies sensitive riparian areas, contributory wetlands (fens), and sediment source areas within the watershed which influence downstream fish habitat.
3. Watershed analyses provide information on which to base a watershed-specific management approach. Current procedures generally focus on site-specific conditions but do not fully consider the physical processes which control watershed equilibrium.
4. The riparian habitat conservation strategy emphasizes the role of fens, which contribute base flow, nutrients, thermal protection, and other benefits to fish habitat.
5. The riparian habitat conservation strategy emphasizes a need for a more complete and accurate riparian database for decision-making. It also defines the baseline inventory data against which changes in watershed conditions can be measured.
6. Field verification of the riparian management area (in conjunction with site analysis) should streamline timber sale planning and improve both timber harvest unit layout and road location. This improvement would result in better disclosure of potential environmental impacts to the public.

In conclusion, the riparian habitat conservation strategy developed by the Alaska Region focuses attention on the natural processes within the watershed which control stream channel equilibrium and ultimately affect fish habitat. Watershed analysis, used to delineate riparian management areas, provides a formalized framework for implementing resource protection measures identified under current procedures. Application of Best Management Practices (under current procedures) maintains a focus that is driven by individual site-specific factors, whereas the riparian habitat conservation strategy gives maximum consideration to the physical processes that affect the watershed. By aggressively implementing all Best Management Practices, in particular, Best Management Practice 12.1 (*Cumulative Watershed Effects Analysis*), the Forest Service potentially has the ability to provide fish habitat protection equivalent to that of the riparian habitat conservation strategy.

Region 10 Watershed Analysis

Chapter 4

Evaluation of Pilot Watershed Analysis Process

Overview

The preamble to the Organic Administration Act of 1897 (the enabling legislation for the Forest Service) states:

No national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of *securing favorable conditions of water flows*, and to furnish a continuous supply of timber for the use and necessities of the citizens of the United States...[16 U.S.C. 475; emphasis added].

Citizens, government officials, and politicians of the time concluded, through what may be described as watershed analysis, that abusive treatment of watersheds was resulting in unfavorable downstream conditions that were not in the interest of the nation. Three quarters of a century later, the Clean Water Act (Section 208), and the National Environmental Policy Act require that "cumulative effects" be considered. This requires analysis that is similar to watershed analysis, the difference being that the watershed analysis is place-and-process driven, rather than project driven. Understanding the physical functions and processes that characterize and control the equilibriums that exist between a watershed and its stream channel system are an important part of watershed analysis and an essential element of ecosystem management.

During the development and application of pilot watershed analysis in the Alaska Region, Part 1 of the *Federal Agency Guide for Pilot Watershed Analyses* [*Federal Guide*] was found to be valuable. The primary use of Part 1 was for formulating the plan of work for the watershed analyses and to help explain what watershed analysis is. However, clearly articulating the intent of watershed analysis to land managers and the public, particularly how watershed analyses is used in making natural resource management decisions, continues to be difficult. The development of an education and communications strategy is an important element that should be addressed.

Part 2 of the *Federal Guide* was helpful in understanding what was expected from watershed analysis. It currently has limited application, however, because of the lack of depth of the existing modules and the complete absence of other modules that are essential for watershed analysis in our coastal rainforest environment..

Watershed Analysis as Applied on the Tongass National Forest

The Tongass National Forest is unique in that it is composed of three administrative areas (Areas) that are administered like separate national forests. However, the Tongass National Forest has a common land management plan (Tongass Land Management Plan or TLMP) and is subject to the Tongass Timber Reform Act. Each of the three Areas have differences in

organization, staffing, priorities, and databases. The Regional watershed analysis team (Regional team) was formed to achieve consistency in the conduct of watershed analyses by the Areas and also to act as a coordination and technology transfer team. The Regional team was given lead responsibility to

- 1) keep the lines of communication open between the Areas;
- 2) craft and facilitate a Memorandum of Understanding with Sealaska for access to their lands;
- 3) formulate and adapt protocols and procedures for the Tongass National Forest
- 4) ensure compliance with agreed-upon protocols; and
- 5) deliver the required information in a timely manner.

The Regional team reviewed the *Federal Guide* (Part 2) modules and compared them with protocols used in Alaska. With the exception of the *Federal Guide* module on channel condition (pp 2-88 to 2-93), the Regional team developed its own protocols for conducting the watershed analyses.

The Area watershed analysis teams (Area teams) were comprised of the technical personnel available from each Area. The team leader from each of the three Area teams were also members of the Regional team. The Area teams actually performed both the office and field phases of the individual watershed analyses. The Area teams produced a watershed analysis reflective of their differing levels of data and staffing, GIS capability, and Area commitment (see Management Challenges).

The Regional team brought together an interagency, interdisciplinary team of scientists and professionals. This team worked across discipline and agency lines (i.e., research and management; fisheries, hydrology, and other disciplines; State and Federal agencies; Regional and Forest levels). The combined efforts of the Regional team and the Area teams have begun to establish the state-of-the-art for watershed analysis in Alaska.

Direction and Guidance

The Forest Service has re-emphasized the need to consider state-of-the-art scientific information when making management decisions. Current management direction is moving towards landscape-level analysis of the ecosystem. Application of state-of-the-art scientific information through watershed analysis is a key building block for this landscape-level analysis and serves as a tool for development of future land management programs and projects.

Watershed analysis is an evolving process and iterative in nature. Data gathering and analysis techniques are refined, as appropriate, to consider additional information, changing conditions, and potential effects associated with long-term management issues. A transition period is needed to allow for: 1) procedures and analysis techniques to be developed; 2) training; 3) budgets and staff to reflect the work required; 4) and completion of the surveys, analyses, and planning.

Another purpose for conducting the pilot watershed analyses was to test the selected protocols and procedures and to gain the experience needed to conduct an effective watershed analyses. This is both important for defining our current monitoring needs and for determining what is required if it is decided to use watershed analysis as a process required as part of the implementation of ecosystem management.

Some challenges encountered have been recognized by the Regional leadership team. If the Regional leadership team decides to implement watershed analyses on a continuing basis, there is a need for additional guidance based on the experience gained to date. Topics which need to be addressed include technical and management challenges.

Technical Challenges

In conducting the three pilot watershed analyses, a number of technical challenges were identified that need to be addressed if accurate and timely watershed analysis reports are to be produced in the future.

1. **GIS Coverage and Accuracy.** Geographic Informations Systems (GIS) and other spatial databases are an integral part of watershed analysis. On the Tongass National Forest, these databases and the ability to manipulate them is less than adequate for efficiently conducting watershed analyses. Incomplete inventories, inconsistent digitizing, and funding and staffing deficiencies have all reduced the reliability and performance of the GIS in conducting watershed analyses. The shortcomings of each of the primary coverages used in analyzing the watersheds are described in Appendix 5.
2. **Equipment.** Modern computer workstations are needed to adequately manipulate the great body of information (needed for watershed analyses) that is stored in the Tongass National Forest databases. Our present computer hardware and software are inadequate for efficient and effective watershed analyses. Some computer models cannot be run effectively without the automated capability of the GIS. The GIS allows the production of images of broad landscape patterns that are of great use in fostering interdisciplinary and interagency understanding of the watersheds and landscapes we manage.

Referencing data to accurate and reliable geographic positions is becoming much more important as data volume and diversity increase and as increasing location accuracy is required. The geographic information system demands a minimum level of positional accuracy that is best obtained with geographic positioning systems. The use of geographic positioning systems technology by all field personnel and a formal system of GIS coverage verification should greatly reduce accuracy problems.

3. **Database Extent, Reliability, and Consistency.** An adequate and consistent database is a prerequisite for describing and understanding the processes that control erosion, streamflow, and fish habitat as they respond to natural and

management-related disturbance. Quantitative data should be collected in a systematic manner over a timespan long enough to indicate trends. Such a database is lacking on the Tongass National Forest and has limited the ability of the pilot watershed analyses to draw definitive conclusions.

Rules and conventions in the form of protocols must be developed and implemented for consistent data collection to ensure the quality, usefulness, and longevity of the information and databases. These protocols must be complete yet flexible guidelines that all information management activities must adhere to, and they must be based on the needs of the primary users.

4. **Fish Habitat Objectives.** The fish habitat objectives were in a state of refinement until after the Area reports were due. This prevented the Area teams from conducting additional field work to explain some apparent contradictory results. A major concern was the accuracy and reliability of the fish habitat objectives. The fish habitat objectives have an inadequate sample size for some channel types. In addition, the protocols for defining how pools and large wood debris are measured have not been consistent over the years or even between Areas (see Appendix 1 of fish habitat analysis team report. This sometimes resulted in questionable and/or contradictory interpretations of fish habitat condition.

The Stikine and Ketchikan Area team reports provides examples of a problem which surfaced during the analysis process. Using the width/depth ratio as an indicator, the lower part of the watershed appears to be severely aggraded. However, a look at the percent pool area suggests that the system is healthy from a fish habitat perspective. Future guidance should refine data collection protocols used to establish fish habitat objectives so that their full use as fish habitat assessment tools is realized.

5. **Stream Classification.** There are two basic types of stream classification used in the Alaska Region. One classification defines the value of the stream system. This classification is defined in the *Regional Aquatic Habitat Management Handbook [AHMU Handbook]* (Forest Service Handbook 2609.24, June 1986). The *AHMU Handbook* recognizes three stream classes:

- Class I contain anadromous fish or high-value resident fish.
- Class II contain resident fish.
- Class III are nonfish-bearing streams that can influence the water quality of Class I and II streams.

The other classification system defines the geomorphic processes that occur within the stream channel and within the influencing landscape. This classification system is defined in the *Channel Type User Guide, Tongass National Forest, Southeast Alaska [User Guide]* (R10-TP-26, April 1992). The *User Guide* recognizes nine process groups and a total of 38 individual channel types:

- Estuarine Process Group (E)
- Palustrine Process Group (P)
- Flood Plain Process Group (FP)
- Glacial Outwash Process Group (GO)
- Alluvial Fan Process Group (AF)
- Large Contained Process Group (LC)
- Moderate Gradient Mixed Control Process Group (MM)
- Moderate Gradient Contained Process Group (MC)
- High Gradient Contained Process Group (HC)

The channel-type classification was extremely helpful in determining what fluvial geomorphic processes control the natural dynamic equilibriums that exist within each channel type. The individual stream segments defined by both of these stream channel classification systems are mapped and entered into the GIS data base.

Each stream class has specific guidelines for protection, including buffer width and yarding restrictions. As the pilot analyses proceeded, it became clear that many Class III channels (which are non fish-bearing but are primary tributaries leading from the hillslope to Class I and Class II streams) were improperly located or not displayed on existing GIS layers. Since the Class III streams cover such a wide range of channel types and stream sizes (from major perennial tributaries to relatively insignificant perennial and intermittent drainages), it is difficult to establish meaningful management prescriptions for their protection. Currently, Class III streams must be considered on a case-by-case basis in the field. A fourth stream value class (Class IV) is needed to identify channels that require minimal protection to maintain their channel integrity. This need was previously identified (Kuehn, et al., Nov. 1989, unpublished).

6. **Potentially unstable soils.** The identification of potentially unstable soils used established Area protocols based primarily on soil type and slope gradient. There are slight differences in the way the Areas have defined their potentially unstable soils. This results in differences in the delineation of the potentially unstable soils that make up the riparian management areas. The parameters are good general indicators of soil stability and erosion hazard but fail to specify micro-topographic and drainage characteristics critical to sediment generation and the transport of both sediment and LWD from hillslopes to the stream system. Linear hollows and shallow swales, with no clearly definable channels, are widespread within these potentially unstable soil areas and need to be identified and located both on field maps and within the appropriate GIS layers. Such features serve to focus groundwater flows during storms and are common points of origin for landslides. They are also primary transport paths for delivering sediment and LWD from the hillslope to the stream channel. The lack of identification of these features and their areas of concentration seriously hampered effective application of both the landslide hazard protocol and the sediment transfer hazard protocol and limited the ability of the watershed analysis teams to define riparian management area boundaries.

7. **Monitoring/Data Collection Procedures.** The pilot watershed analyses utilized existing information to the greatest extent possible. New information was collected to fill in crucial data gaps where necessary and practical. The analysis process highlighted the fact that certain types of data which have been collected during the past several decades are of limited value and have not been used in the watershed analyses. The following problems were encountered for which additional guidance is needed.
- For many parameters, standard protocols or procedures should be developed so that results are repeatable and statistically significant data is obtainable.
 - Objectives for use of the information must be better defined and data collection efforts better coordinated.
 - Monitoring or sampling sites should be better stratified and selected to best represent the population being monitored.

For an expanded discussion of monitoring refer to Appendix 6.

8. **Protocols/Analysis Modules.** Protocols were developed by the Regional team using modifications of protocols developed by the Areas and adaptations of protocols from outside the Region. Application of these protocols clearly demonstrated the need to improve the reliability and consistency of data and information used to drive them. There is also a need to improve the accuracy at which variables are measured and reported and to calibrate specific protocols such as the riffle stability index (RSI) to reflect conditions and trends specific to Southeast Alaska. The pilot watershed analyses identified the sediment transport hazard and riffle stability index (RSI) protocols and the blowdown assessment procedure as needing improvement:
9. **Cumulative Effects Methodology.** Information from watershed analysis should be suitable for inclusion into NEPA documentation for specific projects. There is a need to improve the understanding of the ecological functions, processes, and interactions that occur within a watershed. Watershed analysis should provide information useful for estimating the direct, indirect, and cumulative effects (including risks) of management proposals in a watershed. An important element missing from the pilot watershed analyses was a methodology for assessing cumulative effects of natural processes and management impacts on aquatic habitat. At the present time, the Tongass National Forest has no agreed-upon protocol or methodology for assessing the risk or potential for cumulative watershed effects or to evaluate the acceptable risk for management activities. However, the Stikine Area has developed a preliminary model that has proved successful through the NEPA process.

Management Challenges

If watershed analysis is to be a integral part of the National Forest System and/or ecosystem management, substantial commitment will be required to provide the appropriate technology, funding, staffing, and priorities needed to accomplish the task. The expense, time, and skill levels required for thorough analyses are substantial. Listed below are elements that the pilot watershed analyses demonstrated to be essential to conducting effective watershed analyses and producing timely reports. These elements, although separated here, are closely linked and each must be in place and functioning to produce accurate and cost-effective watershed analyses.

1. **Authority.** An appropriate level of authority is necessary to set priorities and/or control funds across functional and administrative levels to efficiently produce timely and consistent watershed analysis reports. The Regional team was not given this authority. Therefore, the three administrative areas (Areas) and the various staffs within the Regional office assigned significantly different priorities for conducting the watershed analysis, which caused delays and inefficiencies.
2. **Consistency.** The Tongass is unique in that it is one forest with three supervisor's offices. Each office has a GIS shop and builds and updates coverages for their area. When a forest-wide analysis is needed, the coverages of each Area are collected and combined. Rules and conventions in the form of protocols must be developed and implemented to ensure the quality, usefulness, and longevity of information and databases.
3. **Staffing.** The issues driving watershed analyses on the Tongass are related to the interaction between forestry and fish management needs as they interact at the watershed scale. Therefore, a watershed analysis team on the Tongass should be composed of journey-level professionals from the disciplines of hydrology/geomorphology; fisheries biology/aquatic ecology, and forestry/engineering. In addition to one fulltime member from each of the above categories, a GIS/computer specialist and a writer-editor are required on at least a halftime basis. Depending on the issues involved in the analyses, additional disciplines may be required. Generally, a team structure will consist of
 - a. a team leader
 - b. two team members (from the abovementioned disciplines but not of the same discipline as the team leader);
 - c. GIS computer support (one person for two teams);
 - d. a writer-editor (one person for two teams); and
 - e. field support (from current workforce).

Appendix 1

Chronology

Appendix 1

The following list of meetings and milestones is offered to indicate what was involved in coordinating the watershed analysis process:

- Oct. 14 The Regional Leadership Team met and considered establishing the Regional Watershed Analysis Team (RWAT).
- Oct. 14 The Alaska Working Group on Cooperative Forestry/Fisheries Research (AWGCFFR) was briefed on the Pacfish strategy.
- Oct. 26 A teleconference was held to brief potential RWAT members and get them thinking about the criteria for selection of candidate watersheds.
- Nov. 9 The AWGCFFR was briefed on the possibility of conducting watershed analysis in response to the FY 1994 Appropriations Act.
- Nov. 17 The Regional Leadership Team made a tentative decision to proceed with one pilot watershed analysis on each of the three Tongass administrative areas.
- Nov. 17 A letter was received from Senator Stevens requesting the Forest Service work with the AWGCFFR in "setting the parameters of the studies."
- Nov. 22 The RWAT members were confirmed. A teleconference was held to discuss plan of attack and schedule of work.
- Dec. 7-9 The first RWAT meeting was held to accomplish the following:
1. Draft criteria for watershed boundary delineations
 2. Draft Regional issues statement as proxy for River basin Assessment as required by the Federal Agency Guide for Pilot Watershed Analysis.
 3. Draft criteria for pilot watershed selection
 4. Draft list of potential candidate watersheds
- Dec. 16 The AWGCFFR was briefed on the December 7-9 RWAT meeting. Verbal comments were received from members of AWGCFFR. Written comments were later received from Roger Ziesak of KPC in reference to the issues, and Buck Lindekugel of SEACC in reference to the selection criteria, candidate watersheds, issues, and public involvement.
- Jan.19-21 The second RWAT meeting was held to accomplish the following:
1. Determine how to use GIS Workstation(s)
 2. Learn the history and application of the Federal guide for Pilot watershed Analysis
 3. Draft list of candidate watersheds

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4. Discuss the identified issues and comments received from KPC and SEACC. The draft issues were reorganized into types, and River basin and Regional issues were cross referenced and refined.
- Jan. 27 AWGCFFR was briefed at the January 19-21 RWAT meeting and draft notes from the meeting were distributed. Verbal comments were received from members of AWGCFFR pertaining to the openness of the process and candidate watersheds.
- Jan. 31 The draft list of key parameters was received from FHAT. This list of parameters would be used to measure the stream channel system as it relates to fisheries habitat.
- Feb. 17 An RWAT teleconference was held. The following topics were discussed and confirmed:
1. A list of potential candidate watersheds was reviewed for completeness and confirmed.
 2. A list of candidate watersheds was reviewed and confirmed.
 3. The three study watersheds were confirmed.
- Feb. 22 An RWAT teleconference was held to give assignments for the review of the issues statement and the parameters list. It was agreed that the issues driving watershed analyses were directly related to fisheries habitat protection and that additional basinwide surveys were needed.
- Mar. 3 The AWGCFFR was briefed on the RWAT activities. Final notes from the 1/19-21/94 RWAT meeting and the 2/17/94 RWAT teleconference were distributed.
- Mar. 22-25 The third RWAT meeting was held to accomplish the following:
1. Confirm that the schedule would not be relaxed
 2. Discuss issues related to FACA
 3. Discuss how we could work with Sealaska
 4. Discuss how we could work the CWE contract into the WA
 5. Discuss when and how we would utilize the RHMOs generated through the updating of the Channel Type Attributes Data Base.
 6. Present and discuss the Areas Watershed Analysis Study Plans, and agree to the objectives that would be common to all study plans
 7. Discuss and come to agreement on the general protocols that would be used for the collection and analysis of the required data.
- Apr. The office phase of watershed analysis is underway
- Apr. 7 The AWGCFFR was briefed on the March 22-25 RWAT meeting and the Interim Report to the Appropriations Committee.

Appendix 1 - Chronology

- Apr. 8-20 Draft protocols were received.
- Apr. 11-12 Final Area study plans were received.
- May 5 The AWGCFFR was briefed on the progress of the watershed analysis including status of AWAT work plans, protocols, and the Memorandum of Understanding (MOU) with Sealaska to share information on the Game Creek and Old Franks watersheds. Verbal comments were received from members of AWGCFFR.
- May 20 The MOU between Sealaska and the Forest Service is signed.
- Jun. 2 The AWGCFFR was briefed on the progress of the RWAT and AWATs. Copies were handed out of the: 1) AFHA, June 94 LTM briefing; 2) final March 22-25 RWAT meeting notes; and 3) signed MOU for scientific study and access between Sealaska and the Forest Service.
- Jun. The field phase of watershed analysis is underway.
- Jun. 29 The fourth RWAT meeting was held to accomplish the following:
1. Discuss the status of each of the AWAT reports
 2. Discuss status of the ecomap and landscape delineation
 3. Discuss the definition of the RHCA (It was agreed that the Chatham procedure was the desired procedure.)
 4. Confirm objectives for the analysis as stated in the March 22-25 meeting notes
 5. Receive draft of the RHMOs from FHAT
 6. Confirm that protocols were mandatory if applicable
 7. Review protocols (It was determined that the Stream Class III and IV protocol should be deleted, since there was not enough time to deal with it. The landscape delineation and the Cumulative Watershed Effects (CWE) protocols were also deleted because they would not be delivered in a timely manner.)
 8. Confirm the AWAT and RWAT schedules
- Jul. 19-30 AWAT and RWAT reports drafted.
- Aug. 2 Draft AWAT reports and first three chapters of the RWAT Report are delivered to the FHAT
- Aug. 4 AWAT Team leaders give a presentation on their respective reports to the FHAT and take questions from the FHAT.
- Aug. 4-15 With comments received from the FHAT and each other, the AWATs and the RWAT prepare final drafts of their reports
- Aug. 16-26 With comments received from the FHAT and each other, the AWATs and the RWAT prepare their final reports

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Appendix 2

Regional and Riverbasin Issues

Appendix 2

On Dec. 9, Ron Dunlap, Jim Ferguson, and Mike Kuehn reviewed the public comments that were received through the TLMP Revision DEIS and SDEIS processes. They worked off a "Summary of Substantive Comments of Potential Interest for Watershed Analysis" as produced by B. Rene (5/22/92) and modified by S. Kessler (11/22/93). These comments were consolidated into eight issues specific to the Tongass National Forest and Southeast Alaska in general.

1. The impacts of unstable hillslopes and sensitive soils are not adequately considered during the NEPA process and during project implementation.
2. Riparian habitat may not be adequately protected.
3. Because the contribution of wetlands to the protection of water quality and fisheries habitat are not identified at the watershed and/or project level, the function and value of wetlands are not adequately considered.
4. There is no commonly recognized or adequate method that is used for conducting cumulative watershed effects analysis (CWE) or for assessing the risk of impacting water quality and fisheries habitat.
5. There may not be adequate maintenance of sufficient diversity within the fisheries community to ensure long-term productivity of all the identified stocks.
6. The maintenance of habitat complexity may be inadequate.
7. The consideration of estuaries in the management of fisheries habitat is inadequate.
8. The monitoring program for ensuring the protection of water quality and fisheries habitat is inadequate.

Watershed Analyses - Pacfish Issues

On December 15, 1993, list of statements and comments were compiled from the Pacfish Strategy Executive Summary as revised September 29, 1993, that could be used to define issues. This information was condensed into the following preliminary issue statements:

1. The maintenance of salmon stock diversity throughout their range may be inadequate to ensure long-term sustainable salmon production.
2. Understanding the processes and functions of aquatic ecosystems at the landscape level may be inadequate to ensure the viability of Pacific salmon stocks.

3. Management and fish and aquatic ecosystem researchers may not be applying the best science or most current research findings.
4. Some salmon steelhead and cutthroat stocks in Alaska may not be secure as a result of past practices that degraded fisheries habitat.
5. Current fisheries habitat functions and values may be less than optimum as a result of past and possibly current management practices.
6. The understanding and/or application of terrestrial and aquatic ecological principles may be inadequate to maintain fisheries stocks at sustainable levels.
7. Watersheds should be identified which are important for stocks at risk, in "good" condition, or that have a high potential for restoration to provide a pattern of protection across the landscape.
8. The science and application of cumulative effects and or watershed analyses may be inadequate to maintain fisheries stocks at sustainable levels.

The RWAT reviewed the issues summarized from both the input to TLMP and issues taken from Pacfish. With the exception of the issue relevant to knowing what stocks are potentially at risk, the eight issues from TLMP (Riverbasin Assessment level) cover all of the issues identified from Pacfish (Regional Assessment level). The RWAT discussed all the identified issues and input received from Ketchikan Pulp Corporation and Southeast Alaska Conservation Council. The issues were reorganized into types, and Riverbasin and Regional issues were cross referenced, and Regional (Pacfish) issues were consolidated and redefined as follows:

1. Is salmon stock diversity adequate to insure long-term sustainable salmon production? (TLMP issue #5 responds to the habitat part of this issue).
2. Is the understanding of the processes and functions of terrestrial and aquatic ecosystems at the landscape level adequate to ensure the viability of Pacific salmon, steelhead, and cutthroat stocks? (All eight TLMP issues, but particularly #4 respond to this issue. This is what watershed analysis is all about).
3. Is management applying the best science or most current research findings? (All eight TLMP issues, but particularly #4 respond to this issue. This is what watershed analysis is all about).
4. **DELETED** - covered under and/or incorporated into # 2 and 5.
5. Are current fisheries habitat functions and values less than optimum and/or outside the range of natural variation as a result of past and possibly current management practices? (All eight TLMP issues respond to this issue. This is what watershed analysis is all about).

Appendix 2 - Regional and Riverbasin Issues

6. **DELETED** - covered under and/or incorporated into # 2 and 5.
7. Watersheds should be identified which are important for stocks at risk, in "good" condition, or have a high potential for restoration to provide a pattern of protection across the landscape. **This is a Regional issue that may not be valid for Alaska, and it can not be dealt with at the watershed analysis scale.**
8. Is the science and application of cumulative effects and/or watershed analyses adequate to maintain fisheries stocks at sustainable levels? **(TLMP issue #4 responds to this issue).**

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Appendix 3

Watershed Selection

Appendix 3

In response to a request from FHAT, Mike Kuehn (RWAT Leader) asked for a list of all potential candidate watersheds. These watersheds are: (1) covered by a Post-TTRA ROD or a Pre-TTRA ROD modified to meet TTRA; (2) have a significant amount of Class I streams/habitat; and (3) over 10 square miles in area. The potential candidates are:

Table 3-1. Potential Candidate Watersheds

Watershed Name	VCU	Sale Name	Area square mi.	Signif. Fishery
<u>Chatham Area</u>				
Game Creek	204	AK. Pulp Corp. (86 -90)	35	yes
Corner Bay Creek	236	"	>10	yes
Kook Creek	239	"	>10	yes
False Island	245	"	>10	yes
Sitkoh Bay	243	"	25	yes
Wukuklook Creek	210	"	>10	yes
Gypsum Creek	212	"	>10	yes
N.F. Freshwater Cr	215	"	>10	yes
Upper Pavlof Creek	218	"	>10	yes
Buckhorn & Whale Cr	238	"	>10	yes
Upper Whiterock Cr	242	"	>10	yes
Sales in limbo pending outcome of AK Pulp Corp. contract				
Saltery Bay	231	AK Pulp Corp. SE Chich. (92)	>10	yes
Crab Bay	232	"	>10	yes
South Crab Bay	233	"	>10	yes
Broad Creek	246	"	>10	yes
Saook Bay	294	AK Pulp Corp. Kelp Bay (92)	>10	yes
Appleton Cove	293	"	>10	yes
<u>Ketchikan Area 1/</u>				
Upper Thorne Lake	575	Ketch. Pulp Corp. (89-94)	15	Yes
Old Franks Lake/Cr	613	"	25	Yes
Upper Old Franks Cr	613	"	16	Yes
Angel/Goose/Rush Crs	597	"	20	Yes
Rio Beaver Creek	597	"	14	Yes
Hatchery Creek	574	"	>20	Yes
Harris River	622	"	>25	>10
Shaheen Creek	589	"	>15	Yes
Dog Salmon Creek	620	"	>10	Yes
Flicker Creek	529	"	10	Yes
Salmon Bay Lake	534	"	27	Yes
Logjam Creek	577	"	>25	Yes

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Staney Creek	588, 590	"	>40	Yes
Luck Lake/Eagle Cr	581	"	>10	Yes
Salt Creek	747	Shelter Cove (91)	15	Yes
Traitors Creek	737	North Revilla (93)	20	yes
Margaret Creek	738	"	15	yes
North Thorne River	580	Central POW (93)	15	Yes
Ratz Creek	583	"	>10	Yes
Hatchery Creek	574	"	>20	Yes
Naukati Creek	571	"	15	Yes
<u>Stikine Area</u>				
Duncan Creek	424, 441	Bohemia Mtn. (9-91)	>10	Yes
Pump Creek	464	Starfish (9-91)	9	Yes
Fishtrap Creek	464	"	12	Yes
Logjam Creek	467	"	9	Yes
Kadake Creek	421	AK Pulp Corp. N & E Kuiu (1-93)	50	Yes
Rowan Creek	402	"	>10	Yes
Tom Creek	510	Campbell (9-93)	>10	Yes
Portage Creek	442, 444	Portage Salvage	>10	Yes
Frosty Creek	524	Frosty Bay (12-90)	16	Residents
Brown's Creek	402	SEIS (Long-term) (89)	>10	Yes

1/ Most of the Ketchikan Area pilot watershed candidates listed above saw harvest activities in the 1970s and 1980s. In many cases (Staney, Slide, North Thorne, Logjam, Harris R., etc.) the cumulative activity levels would have to be considered very high, resulting in potentially great difficulty in separating pre-TTRA activity effects on habitat from post-TTRA. In addition, some of the post-TTRA entries were very minor compared to the great number of pre-TTRA entries. Finally, access to systems at the North End of POW, and lack of facilities, make consideration of North POW systems logistically difficult for the FY94 assessment exercise.

Of the 48 potential candidate watersheds listed above 10 were selected as candidate watersheds to be looked at in more detail (Table 3-2).

Table 3-2. Candidate Watersheds

<u>Selection Criteria</u>	<u>Chatham Area</u>				<u>Ketchikan Area</u>			<u>Stikine Area</u>		
	<u>Corner</u>	<u>Game</u>	<u>Kook</u>	<u>Sitkoh</u>	<u>Salt</u>	<u>Traitor</u>	<u>OFrnk</u>	<u>Kadake</u>	<u>Pump</u>	<u>Duncan</u>
Post TTRA activity date ROD signed	Y 89	Y 89	Y 89	Y 89	Y 91	Y 10-93	Y 89	Y 1-93	Y 9-91	Y 9-93
Representative WS	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Diverse Aq Com Str	Low	High	Low	High	High	Mod	Mod	High	High	High
Habitat Complexity	Mod	High	High	High	High	Mod	High	High	High	High
Mgmt Intensity	High	High	High	High	Low	High	High	High	Mod	Low
Data available	Mod	High	Mod	Low	Low	Mod	High	Mod	Low	Low
Accessibility	High	High	High	High	Low	Low	High	High	Mod	Low
Public Interest	Low	High	Mod	Mod	High	High	Mod	High	Low	Low
Natural Sensitivity	Mod	L-M	High	High	High	High	Mod	High	Mod	Mod
Signif Mgmt Activity WS size in sq-mi	Y >10	Y 25	Y >10	Y 25	Y 16	Y 20	Y 16.5	Y 50	Y 9	N >10

The above table is a display of the tentative candidate watersheds. The name of the tentatively selected watersheds are highlighted.

The watersheds selected for the pilot Watershed Analysis were Game Creek, Old Franks and Kadake Creek. Selection was a consensus between the Regional Watershed Analysis Team, the Fish Habitat Analysis Team and the Alaska Working Group for Cooperative Forestry and

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Fisheries Research. Input was also received from Sealaska Corporation, the Alaska Department of Environmental Conservation and the Alaska Department of Fish and Game.

Game Creek (Hoonah Ranger District, Chatham Area) - This watershed is a fourth order basin covering 52.3 square miles (33,467 acres) with the lower 12 square miles in private ownership. The watershed has a moderate amount of timber harvest (1,545 acres), with 29 harvest units on National Forest ownership. Five of these units were harvested before the Tongass Timber Reform Act was enacted. The rest of the units were harvested in 1993 under the Act's guidelines.

Game Creek produces good escapements of pink and chum salmon and coho salmon, Dolly Varden char and cutthroat trout are also present in this system.

Kadake Creek (Petersburg Ranger District, Stikine Area) - This watershed is a fifth order basin covering 50.4 square miles (32,300 acres). A substantial amount of timber (4,700 acres) has been harvested. About 50 timber harvest units were harvested before the Tongass Timber Reform Act. Twelve timber harvest units were planned post-Tongass Timber Reform Act with harvest being completed in some of these units.

The watershed has high fishery values and produces good escapements of pink and coho salmon and steelhead trout. The cutthroat trout population is high. Chum salmon and Dolly Varden are also present.

Upper Old Franks (Craig Ranger District, Ketchikan Area) - This watershed is about 25 square miles and the lower 9 square miles is in private ownership. The watershed has a moderate amount of timber harvest (539 acres). Eight timber harvest units were harvested under post Tongass Timber Reform Act guidelines, and 13 additional units are proposed for harvest.

Since the construction of two fishpasses on Old Franks Creek, anadromous runs of coho salmon and sockeye have been increasing. The system also receives runs of pink salmon and steelhead trout. Cutthroat trout and Dolly Varden char are also present in the system.

Appendix 4

Critical Variables and Protocols

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Appendix 4

Critical Variables and Protocols for Pilot Watershed Analyses in the Alaska Region

Data Type	Information source	Analytical Protocols and Working Tools
<u>Terrestrial Elements</u>		
Topography	GIS	Digital elevation model (DEM)
Geology	USGS maps; GIS maps; individual reports	Digitized into GIS
Aerial Photography	Regional and Area photo libraries, 1929 to present	Training and experience
Landforms, soils, and vegetation		
Mass-movement hazard rating	Landslide inventories; GIS analysis; photo interpretation; field verification	GIS common land unit (CLU) rating; field reconnaissance; application of Protocol #1 - Mass-movement (landslide) Hazard Protocol (Swanston and Loggy 1994)
Sediment transfer hazard rating; hillslope drainage frequency	GIS, photo interpretation; field verification	Field reconnaissance; application of Protocol #2 - Sediment Transfer Hazard Protocol (Loggy 1994); Hillslope Traverse Procedure (Kelliher 1994)
Forest vegetation cover	GIS	GIS forest vegetation layer (CLUVEG)
Riparian vegetation cover	GIS	GIS riparian vegetation layer (CLURIPAR) as defined by Cowardin, Carter, Golet, and LaRoe (1979) ¹
Wetland cover	GIS	GIS wetland cover layer (CLUWET) as defined by Cowardin, Carter, Golet, and LaRoe (1979); DeMeo and Loggy (1989) ² ; and Brinson (1993) ³

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Snow avalanches	GIS	GIS forest vegetation layer (CLUVEG) which displays snow avalanche tracks and other nonforested areas
Climatic Data		
Precipitation isohyets	US Department of Interior, Geological Survey	Published isohyetal map and analysis (Jones and Fahl 1994) ⁴
Precipitation isopluvals	NOAA, weather service	Published isopluval maps and analysis (Miller 1963) ⁵
Wind patterns	Aerial photo interpretation; field investigations	Inventories; mapping; analysis
Snowpack	NOAA; weather service; SCS	Published snow-course data and analyses as annual data summaries and monthly reports ⁶
Blowdown	Aerial photo interpretation; field verification	Training; field experience; field reconnaissance
Landslides	Aerial photo interpretation; field verification	Training, field experience; field reconnaissance to determine: number, size, distance material travels; stream class directly effected; length of channel impacted; landslide delivery ratios developed from data for central ratios Prince of Wales Island (Swanston and Johnson, interim analyses)
<u>Aquatic Elements</u>		
Hydrology		
Stream network; channel type; hillslope drainage frequency	GIS; field verification habitat surveys	Field reconnaissance; application of Protocol #3 - Channel-type Verification Protocol (Paustian 1994); Channel-type Users Guide (Paustian, et al. 1992) ⁸ ; Hillslope Traverse Procedure (Kelliher 1994)

Appendix 4 - Critical Variables and Protocols

Storm flow	Published records; USGS models; USFS models	USGS step-backwater analyses; application of USFS FLOWMOD
Base flow	Published records; USGS models; USFS models	USGS step-backwater analyses; application of USFS FLOWMOD.
Groundwater	GIS; field verification; geologic maps	Use of geologic and vegetation maps, coupled with airphoto analysis and field reconnaissance to identify potential sites of concentrated groundwater flow; installation of simple groundwater wells for flow-net construction.
Channel Morphology		
Channel stability	Field reconnaissance; field measurements	FEMAT guide; Watershed Analysis Guide pp. 2-91; application of Protocol #4 - Riffle Stability Index Protocol (RSI) (Wolanek 1994).
Bankfull width	Field measurements	Application of Protocol #3 - Channel-type Verification Protocol; field measurements; Channel-type Users Guide.
Bankfull depth	field measurements	Application of Protocol #3 - Channel-type Verification Protocol; field measurements; Channel-type Users Guide.
Stream gradient	GIS; field measurements	Application of Protocol #3 - Channel-type Verification Protocol; field measurements; Channel-type Users Guide.
Substrate classes	Field measurements; monitoring	Application of Protocol #3 - Channel-type Verification Protocol; field measurements; Channel-type Users Guide.

Water Quality

Conductivity	STORET; WATSTORE; field measurements; monitoring	Standard methods
pH	STORET; WATSTORE; field measurements; monitoring	Standard methods
Alkalinity	STORET; WATSTORE; field measurements; monitoring	Standard methods
Sulfate	STORET; WATSTORE; field measurements; monitoring	Standard methods
Macroinvertebrates	field sampling of selected reaches; monitoring	Use of Milner and Oswood sampling techniques (Milner and Oswood 1990)*; application of Protocol #5 - Macroin- vertebrate Sampling Protocol (Thompson and Ferguson 1994)

Stream Habitat

Large wood (LWD) (number, diameter, length)	Field measurements	Interim analysis of Regionwide habitat survey data (FHAT, Coghill); application of Protocol #6 - Basinwide Survey Protocol (FSL, Wright); field surveys
Pools formed by LWD (number)	Field measurements	Interim analysis of Regionwide habitat survey data (FHAT, Coghill); application of Protocol #6 - Basinwide Survey Protocol (FSL, Wright); field surveys
Pool type and frequency (number)	Field measurements	Interim analysis of Regionwide habitat survey data (FHAT, Coghill); application of Protocol #6 - Basinwide Survey Protocol (FSL, Wright); field surveys

Appendix 4 - Critical Variables and Protocols

Pool volume (residual)	Field measurements	Interim analysis of Regionwide habitat survey date (FHAT, Coghill); application of Protocol #6 - Basinwide Survey Protocol (FSL, Wright); field surveys
Pool depth (maximum)	Field measurements	Interim analysis of Regionwide habitat survey date (FHAT, Coghill); application of Protocol #6 - Basinwide Survey Protocol (FSL, Wright); field surveys.
Fisheries		
Escapement	Alaska Department of Fish & Game (ADF&G)	Analysis of ADF&G data files and published escapement records.
Species present	ADF&G atlas; field measurements	Analysis of ADF&G data files and escapement records; field estimates.
Species distribution	GIS; ADF&G atlas; field measurements	Analysis of ADF&G data files and escapement records; field estimates.
<u>Management Activities</u>		
Roads		
Location; mileage; age	GIS; field verification	GIS roads layer or data dictionary for availability of information; application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.
Maintenance level	GIS; road maintenance objectives; road maintenance class	Review of road maintenance records; GIS data displays; application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.
Surface erosion	Field measurements; available monitoring reports	Area surface erosion monitoring reports; application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.

Stream crossings (number, type, and condition)	Field measurements; available monitoring reports	Fish passage/culvert monitoring pro- cedure; application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.
Mitigation	Field measurements; road maintenance cards	Application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.
BMP implementation	BMP monitoring reports; road maintenance cards; field measurement	Application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.
Units		
Location, acreage, age	GIS; silvicultural databases	Analysis of GIS and database information; field reconnaissance.
Buffer layout	GIS; unit cards; BMP monitoring reports; field measurement	Analysis of GIS and database information; field reconnaissance.
Buffer blowdown	Field measurement; BMP monitoring reports	Analysis of GIS and database information; field reconnaissance.
Mitigation	Field measurements; unit cards	Analysis of existing information; field reconnaissance.
BMP implementation	BMP monitoring reports; unit cards; field measurement	Analysis of existing information; field reconnaissance.
Rock Pits, Sort Yards		
Location; acreage	GIS; road data files; field measurement	GIS road layer; application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.
BMP implementation	BMP monitoring reports field measurement	GIS road layer; application of Protocol #7 - Road Condition Survey Protocol; field reconnaissance.
Stream Rehabilitation and improvements	Engineering reports; monitoring reports	Analysis of existing information; field reconnaissance.

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Region 10 Watershed Analysis

Appendix 4.1
Mass-movement (Landslide) Hazard Protocol
for the
Region 10 Watershed Analysis

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Protocol

During the FY 94 pilot watershed analysis, the following protocol will be initiated. Its purpose is to provide a quantitative basis for assessing how management activities and geomorphic characteristics might influence landslides and, subsequently, impact fisheries habitat.

The protocols are constructed from four kinds of information: landslide type; management related activities; number and type of stream deposition sites; and terrain analysis.

A. Landslide classification

1. Landslides will be identified as one of two types:
 - a. **Debris avalanches.** These are usually relatively dry and may cascade only partly down slope. They occur on the open slope and are not associated with linear hollows or depressions.
 - b. **Debris flows.** These begin as debris avalanches, but because of increased water content, they tend to be channeled in linear hollows and depressions. They generally travel to the base of the slope and beyond as a viscous flow of soil, rock, water heavily laden with soil, or rock and large woody debris. They emanate from v-notch gullies and canyons, usually as the result of temporary damming by a debris avalanche or debris flow from the gully sideslope during periods of high streamflow.
2. The geomorphic characteristics at the site where the landslide begins will be used to identify landslide type and potential hazard from management activities. These include: a) amount and kinds of vegetation, b) watershed type and landtype, c) soil series, and d) mass-movement index ratings.
3. Landslide sites will be located via soil resource inventories, integrated resource inventories, aerial photography, and on-the-ground review of site characteristics—characteristics such as gradient of the failure surface, width and depth of the failure zone, soil series, drainage condition, vegetation cover at the initiation zone, management activity within the initiation zone, and presence or absence of any windthrow activity. Only landslides greater than one half acre will be recorded.
4. Age of landslide occurrence on old growth and harvested areas (including those from roads) will be determined by using sequential air photo coverage.

B. Number and type of stream deposition sites

1. Determine the number and type of landslides directly entering Class I, II, and III streams.

2. Determine length of Class I and II streams altered by direct entry of landslides into these two stream classes.

C. Terrain analysis and related management activities

This part of the analysis of landslides synthesizes landslide information to determine: 1) the frequency of landslides associated with old growth, second growth, and clearcuts; and 2) the density of landslides for total watershed, watershed compartment, landtype association, landform and soil map units, and mass-movement index ratings.

1. Using GIS, identify and map the vegetative polygons of old growth, second growth, and clearcuts, and of land polygons that characterize the watershed, watershed compartments, landtype associations, landforms, soil map units, and mass-movement index ratings (equal to or less than moderate, high, and very high or, in the case of the Chatham Area, extreme high).

Determine miles of existing roads in second growth and clearcuts and by the mass-movement index rating associated with the second growth and clearcuts.

Mass-movement index ratings will be determined by using either the Ketchikan Area's or the Chatham Area's mass-movement index rating systems. Both systems give equivalent index ratings.

2. Using GIS, determine the total area in each vegetative polygon category of old growth, second growth, and clearcut slopes that are rated as having a mass-movement index equal to or less than moderate, high, or very high (extreme on the Chatham).
3. Determine the landslide frequency for each vegetative polygon and associated mass-movement index by dividing the total number of landslides found in a particular vegetative and index polygon by the total area (square miles [mi^2]) in the vegetative and index polygon.
4. Using GIS, determine the total area (square miles [mi^2]) of the watershed, watershed compartments, landtype associations, landforms, and soil map units by their mass-movement index rating of equal to or less than moderate, high, or very high (extreme).
5. Determine landslide density per a particular land and index polygon by dividing the total number of landslides in the land and index polygon by the total area (square miles [mi^2]) in the land and index polygon.
6. Determine landslide frequency occurring from roads within polygons of second growth and clearcuts with a mass-movement index equal to or less than moderate, high, or very high.

Appendix 4.2
Sediment Transfer Hazard Protocol
for the
Region 10 Watershed Analysis

**Using a Sediment Transfer Hazard Classification System Linking Erosion to
Fish Habitat**

June 6, 1994 Revision

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Part I

Watershed Analysis Protocol For Determining Sediment Delivery Hazard to Fish Habitat Using a Sediment Transfer Hazard Classification System: Linking Erosion to Fish Habitat

The Sediment Transfer Hazard Classification System is a system that links upslope erosion that is associated with natural and/or forestry practices to downstream sedimentation of fish habitats. As explained by Hogan and Wilford (1989), the classification system is a:

System based on key geomorphic factors that influence sediment production, transport and deposition. The assessment of downstream hazards is accomplished by viewing the overall watershed as a network of linked tributaries and mainstem channel segments that transfer both water and sediment to the watershed outlet. The system evaluates the sediment transfer characteristics within each tributary and mainstem channel segment and then estimates potential for transfer between different areas of the watershed. Therefore, the sequential arrangement of tributary and mainstem stream channels determines whether or not an upstream sediment source is connected to sensitive environments downstream.

The final product of the system is a sediment transfer hazard map that indicates where sediment production and movement is a potential problem. This is a useful tool because it indicates where special operational measures that control sediment production are most critical.

The system is designed to be used as an operational planning tool. The terrain and stream channel data requirements are obtained from air photographs, topographic maps, terrain maps, and geographic information system (GIS). Field work requirements are minimal."

Criteria and Procedures

The objective of this paper is to describe the protocol that has been developed by the Regional Watershed Analysis Team (RWAT). This protocol is to be used when assessing the sediment transfer hazard on each of the pilot watersheds being analyzed on the Chatham, Ketchikan, and Stikine Administrative Areas of the Tongass National Forest.

An overview of the system is presented in the flow chart in Appendix A, page A-9.

The geographic information system (GIS) will be the main source of the data base. It will also produce the graphics and display the results of the analysis. The following paragraphs describe the protocol. This protocol has been adopted and revised from the paper "Ketchikan Area's Criteria and Procedures For

Use With a Sediment Transfer Hazard Classification System: Linking Erosion to Fish Habitat" (Loggy, 1994). People using the following protocol should become very familiar with the concepts in the paper by Loggy (1994) and Hogan and Wilford's paper: "A Sediment Transfer Hazard Classification System: Linking Erosion to Fish Habitat" (1987). People using the protocol should become very familiar with the concepts in this paper and the parent paper of Hogan and Wilford: "A Sediment Transfer Hazard Classification System: Linking Erosion to Fish Habitat" (1987).

Delineation of Fish Habitat

The initial step is to determine the location of both high- and low-value fish habitat. This defines the stream reaches that are critical from a sediment transportation, deposition, and channel morphology standpoint. Identification of fish habitat on stream reaches will be through GIS identification of Class I and II streams, supplemented by information from fisheries agencies, and field studies by experienced Forest Service personnel.

Geomorphic Description

Geomorphic characteristics of the watershed and channel system are used in determining sediment production, delivery, and throughput (routing). This information and its display on a map can be obtained completely through the GIS data base. The following information is needed to accomplish the task of determining sediment transfer hazard classification.

- * The channel network of the watershed will be divided into tributary and mainstem channels, each with their associated contributing subwatershed (also called sub-basins or compartments).
- * Channel information will be displayed as Class I, II, and III streams along with the channel types. Lakes will also be displayed.

Hillslope Sediment Delivery Potential

There are two components to the assessment of sediment delivery potential: 1) identifying the nature of sediment sources; and 2) evaluating these sources relative to potential sediment delivery to stream channels.

Sediment Sources

Both Loggy, and Hogan and Wilford's systems define two basic types of sediment source: potential and existing. Potential sources are those areas of a watershed that have a potential for producing sediment as a result of certain naturally occurring characteristics (e.g. areas of unstable soils, highly erosive soils, slopes with a high density of channels). Identifying potential source areas can also identify areas in the initial planning stage where management activities such as road construction and timber harvest should

be planned to minimize disturbance as well as minimizing resulting soil erosion and sediment delivery.

These potential sources are identified on interpretive potential erosion hazard maps. The sources will identify homogeneous polygons of potential mass wasting or slope instability. The potential surface erosion in coastal Alaska watersheds is low, since there is a sufficient organic layer protecting the mineral soils in the pilot watersheds. It will not be considered in this analysis. Four classes of slope stability potential corresponding to the Ketchikan Area and Chatham Area Mass Movement Index (MMI) classes are identified.

Special note: Specialists should review the "Mass Movement (Landslide) Protocol for Watershed Analysis" to ensure the use of the correct MMI rating system for determining the different mass-movement classes.

In most forest planning applications, existing sources are natural or background sources, but in some cases, there may be previous logging or other human disturbance that is producing sediment. Existing sediment sources on the pilot watershed will include:

- * areas of mass movement (debris flows, debris avalanches and debris torrents);
- * stream bank erosion from Class III streams on mass-movement areas that are rated as high and very high (HCs, GO5, AF8);
- * existing timber harvest units;
- * and existing roads and rock pits.

Existing sediment sources are grouped into three general types: areal, point, and linear. In this sediment transfer hazard classification system are scale dependent and must be modified to reflect the range of conditions in a specific area. The tables developed for this protocol follow the general process presented in the Hogan and Wilford paper, but criteria and values have been modified to reflect the range of conditions in coastal Alaska. Table numbers in this paper are kept the same as those in the Hogan and Wilford paper to aid users in comparing protocol between the two papers.

Sediment delivery to stream channels

Two management levels are identified to determine sediment delivery from mountain and hillslopes to stream channels: 1) broad planning; and 2) project planning.

The protocol for the three pilot watershed analyses will only use the broad planning level to determine sediment delivery from mountain and hillslopes to stream channels. This level provides an estimate of the existing sediment delivery to both natural channels and those derived from any existing or past management activities.

The broad planning level allows watersheds to be compared at an early planning stage where the sediment delivery is an existing or potential problem. This level of analysis, based upon the spatial occur-

rence and type of existing and potential natural sediment sources, infers direct delivery of sediment from mountain and hillslopes to stream channels. Analysis will be done on each sub-basin or compartment of a watershed.

Analysis at the Broad Planning Level

The initial step is to identify areas of sediment and organic debris produced from any existing sources (e.g., streambank erosion, mass wasting, snow avalanches, past management activities). These sources are obtained from landform data, soils data, channel type information, and aerial photographs and are displayed on a GIS map. The map should cover the entire watershed so all existing sources of sediment production can be determined. Maps will identify areas of similar channel and surface erosion potential and classes of mass-movement.

Key components. There are three key components to the subsequent analysis: 1) access potential and existing erosion Table 7, Appendix A-3; and Table 6, Appendix A-2) and its movement to channels; 2) access routing of the sediment through existing channel networks (Table 9, Appendix A-5); and 3) access potential fish habitat sediment hazard (Figure 6, Appendix A-8).

Components one and two are linked in a matrix to determine the sediment transfer hazard for a specific sub-basin or watershed compartment. The hazard reflects not only the amount of sediment input but also the ability of the channel to transport the sediment. The sediment transfer hazard from Figure 5, Appendix A-7, is then linked in a matrix (Figure 6, Appendix A-8) to determine the potential fish habitat sediment hazard. This sediment hazard reflects the potential for sediment to be deposited in key fish habitat.

[Component One - Potential Erosion]. This procedure rates the sub-basins or watershed compartments according to their potential for erosion and sediment delivery.

This procedure gives a planner the ability early in the planning stages to identify sub-basins or watershed compartments which are naturally unstable. Table 7, Appendix A-3 will be used to determine the natural erosion potential for sediment delivery within sub-basins and this potential will be shown graphically on a map. In the table, surface erosion (i.e., sheet and rill erosion) will be non-applicable, since there is a sufficient organic layer protecting the mineral soils in the three pilot watersheds. Mass movement (debris flows, torrents and avalanches) is the main source of potential sediment in Southeast Alaska and will be the dominant value considered in the table.

Tables 5 and 7, Appendices A-1 and A-3 display instability values as mass movement indices (MMI's) 1-4. MMI 3 and 4, high and very high hazard, can be determined and presented on a map from the GIS data base. MMI areas will be calculated on a square-mile basis to determine the percentage of the total area of sub-basins or watershed compartments. Class III stream drainage density for each MMI 3 and 4 will be calculated in mile/mile² and will be used for the refinement of the class definitions in Table 7. The drainage density is the same as reported for the linear source (Modified Table 6, Appendix A-2).

[Component One - Existing Erosion]. Table 6, Appendix A-2 provides 5 classes (very low to very high) of sediment delivery within sub-basins for existing erosion. Classes are determined by levels of sediment input from one or more of the general erosion types: areal, point, and linear. One or more of the three erosion types will be used, depending on the sources found within any given watershed.

Aerial sources are existing roads, rock pits, and harvest units; landslides are considered point sources; and stream channels are linear sources.

Only roads and associated rock pits within a sub-basin or watershed compartment that are open and managed under maintenance level 3 and 4 will be considered as being a **major** source of erosion. Roads in maintenance levels 1 and 2 or sections of roads in these two maintenance levels will be assessed as additional potential sediment sources through photo interpretation and/or field investigation. Area will be based on 9 acres for every mile of road. Nine acres per mile is the average acres that are effected by building roads on the Ketchikan Area. These 9 acres per mile include the area taken out of production for rock pits, road bed, and road right-away.

Harvest units that have not met stocking levels or are not considered greened up yet will be considered as having 10 percent of their acres involved in erosion when harvest units were cut adjacent to a stream (no buffer), or the harvest unit has a stream or streams within the unit with no buffers.

The Regional Watershed Analysis Team selected the 10 percent value because of the predominant use of cable systems for timber harvest. Soil disturbance monitoring indicates that 10 percent is the average amount of soil disturbance occurring on these harvest units.

Roads, rock pits, and harvest units will be added together to make up the total percent areal sediment source per sub-basin or watershed compartment.

Landslides will be considered as a point source within each sub-basin or watershed compartment. These will be expressed as number of landslides per mi². Only landslides that are greater than 1/2 acre, are not more than 50 percent revegetated, and that terminate directly into a Class I, II, or III stream will be considered as an existing erosion source for sediment delivery. These point sources will be measured as number of point per square mile of sub-basin.

Class III streams that occur on MMI 3 and 4 sites will be considered linear, naturally existing erosion sources. Miles of Class III streams on a per-square-mile basis of the total MMI 3 and 4 acreage (mile/mile²) will be reported. Channel types that are or may qualify as Class III streams include all HC channels, AF8, and GO5 channels. All other stream classes including Class III in MMI 1 and 2 will be considered as producing very low levels of sediment input. All channel types on other MMI areas will be considered as only contributing minimal sediment from their stream bed and stream banks.

[Component Two - Sediment Throughput]. This component is displayed as a sediment throughput overlay map of the channel network defined as sediment throughput class (Table 9, Appendix A-6).

The overlay map that characterizes existing and potential erosion areas for sediment movement to channels at the sub-basin level and the sediment throughput information are linked in a matrix (Figure 5, Appendix A-7) to determine the sediment transfer hazard from a specific sub-basin or **watershed compartment**. Thus, as reported by Hogan and Wilford, "The hazard reflects not only the amount of sediment input but also the ability of the channel to transport the sediment."

The sediment throughput map is then used to determine how effective the channel network is in delivering sediment within and from a sub-basin into fisheries-sensitive areas. In addition, sub-basins or water-

shed compartments can be added together to determine cumulative sediment delivery to fisheries-sensitive areas lower in the watershed. Channels that have a low sediment throughput, predominantly Class 1 or 2 stream channel types, will act as a sediment sink (Table 9, Appendix A-6, Throughput Classes 1-2). Thus, the probability of sediment transfer out of a sub-basin is low (except for very fine sediment) if it has a Class 1 channel within it. As throughput classes increase, the probability of transfer increases. The ability to sequence sediment throughput classes from sub-basin to sub-basin is critical in the overall assessment of impact to fisheries-sensitive areas.

[Component Three]. The third component determines the sediment delivery hazard for Class I anadromous or adfluvial fish habitat (Figure 6, Appendix A-8). Figure 6 is a matrix linking sub-basin sediment transfer hazard through a ratio of Class I and II channel miles to Class III channel miles in each sub-basin or watershed compartment. To determine this ratio for a sub-basin or watershed compartment, measure the Class I and II miles of stream and compare to the miles of Class III stream. Measurement of Class III streams begins from where it enters MMI-3 or MMI 4 areas or where it is impacted by a point source of erosion and ends at the nearest Class I or II stream. The following stream ratios were used to construct the Y axis of Figure 6, Appendix A-8:

Ratio Class I and II to Class III Stream Miles	Subjective Rating
$R > 3$	Very High (VH)
$1.7 < R \leq 3$	High (H)
$0.58 \leq R \leq 1.7$	Moderate (M)
$0.33 \leq R < 0.58$	Low (L)
$R < 0.33$	Very Low (VL)

For example, referring to Figure 6, Appendix A-8, if a sub-basin has a moderate sediment transfer (M) and a high ratio of miles of Class I and II streams to miles of Class III streams (H), the fish habitat sediment hazard potential is low for the sub-basin or watershed compartment and the mainstem Class I stream below the sub-basin or watershed compartment. This low hazard potential persists until another sub-basin or watershed compartment farther down stream produces a higher potential hazard.

The information generated by the potential, and existing erosion maps, and the potential fish habitat sediment hazard rating should be put in narrative form to explain the impacts from existing and potential sediment delivery on each sub-basin or watershed compartment (e.g., where potential sediment is transported and deposited, which sub-basins or watershed compartments are the most critically impacted from natural and past management activities, and proximity of sediment transport areas to critical fisheries habitat).

Part II

Step-by-Step Sediment Delivery Hazard Protocol

The objective of this section is to describe the systematic approach for applying the sediment delivery hazard protocol that will link cumulative sub-basin erosion to fish habitat. This protocol is adopted from the Ketchikan Area's criteria and procedures developed by Loggy (1994).

The following key is a step-by-step tour through the procedure to obtain a sediment delivery hazard for watershed sub-basins or watershed compartments. This key will aid in determining sediment routing through the drainage system and will assist in predicting sediment impacts to fisheries habitat.

KEY

I. Resource needs

A. Obtain from the Geographic Information System (GIS) database:

1. Maps that show:
 - a. Watersheds and associated sub-basins or watershed compartments. Calculate acres and in square miles (Mi²).
 - b. Contours at 40- or 100-foot intervals (40-foot contour intervals preferred).
 - c. Class I, II, and III Streams.
 - d. Channel types for all Class I, II, and III streams.
 - e. Mass-movement index areas; Low = MM 1, Moderate = MM 2, High = MM 3, and Very High = MM 4.
 - f. Existing timber harvest units.
 - g. Existing roads with maintenance levels of 3 and 4.
 - h. Landslides. (Also obtainable from soil inventory data, landform inventory data, or integrated inventory data.)
 - i. Watershed codes.
2. Obtained from aerial photography at 1:15840 (4 inch/mile) or 1:12000 (5.2 inch/mile) scale.
 - a. Interpretation of latest landslides in the watersheds (can be obtained from the landslide protocol process).
 - b. Identification of potential MMI-3 and MMI-4 sites adjacent to streams.
 - c. Measurement of miles of maintenance-level 1 and 2 roads that are a sediment source.

II. Criteria and procedures

A. Basic Resource Information

Develop map in the appropriate scale of needed resource information for watersheds and their sub-basins or watershed compartments. Review the GIS watershed boundaries and stream order to ensure that the watersheds do actually represent logical 4th or 3rd order watersheds. Combine GIS watersheds if necessary to make logical management decisions, but keep present watershed boundaries and labels intact.

1. Watershed labels - Watershed labeling follows the procedures described in R10 Interim Directive No. 1, 2513.2 - Watershed Coding and the internal memo by Daniel A. Marion, titled "Watershed Delineation Procedure", Dated February 24, 1988 (Appendix B).

- a. Those watershed codes that end in the alphabetic characters of B-N, and P-S equal 3rd order or larger sub-basins in large watersheds (Marion, 1988). In actuality, these identified 3rd order or larger sub-basins within larger watersheds themselves consist of several 1st order to 3rd sub-basins or watershed compartments.
- b. For analysis purposes, the 3rd order or larger sub-basins must be further divided into smaller 1st order to 3rd order sub-basins or watershed compartments.

An additional 8th field will be used to identify the sub-basins or watershed compartments and will be added to the four alphabetic and numeric characters of the present sub-basin code. This eighth position is only for analysis purposes and will be a numeric character (1-9).

2. Stream Classes - follow the standard color coding for stream classes: Class I = blue, Class II = red, and Class III = green.
3. Identify all stream classes by channel types. Use the Current channel type codes as identified in the latest edition of "Channel Type User Guide" (April 1992).

B. Fisheries

Determine the location of both high- and low-value fish habitat for both anadromous and residential sport fisheries. Locate these areas on the map. High anadromous value fish habitat areas are in broad blue, high residential sport fisheries areas are in broad red, and low value fish habitat areas are in pink.

C. Broad planning level

1. Component One - potential erosion within sub-basins or watershed compartments

- a. Use Modified Table 7 (Sediment delivery within sub-basins or watershed compartments: potential erosion) to determine the class of potential erosion for each sub-basin. To do this, calculate the following (Appendix A, A-3):
 - (1) Determine the area of MMI 3 and 4 within each sub-basin mi^2).
 - (2) Determine the percentage of MMI 3 and 4 areas within the sub-basin(s) or watershed compartment(s).
 - (3) Determine the miles of Class III streams in MMI 3 and 4 areas and calculate the drainage density on a per-square-mile basis of the MMI 3 and 4 acreage in the total sub-basin.

Example:

- The sub-basin is 4.5 mi^2 ;
- the MMI 3 and 4 areas are 0.75 mi^2 ;
- the MMI 3 and 4 areas represent 16 percent of the area of the sub-basin or watershed compartment;
- and miles of Class III streams in the MMI 3 and 4 areas are 2.6.
- Therefore, 2.6 miles of Class III streams divided by 0.75 mi^2 of MMI 3 and 4 of acreage in the sub-basin or watershed compartment makes the drainage density be $3.46 \text{ mi}/\text{mi}^2$ as the linear source of existing erosion.

2. Component One - existing erosion.

a. Aerial sources.

- (1) Harvest units - Establish identified past harvest units on the map. Calculate the acres of past harvest units that do not meet stocking rates, have not greened up, and that have no stream buffers. Calculate the total area of these units. Harvest unit source area is determined by taking 10 percent of the total acre amount.
- (2) Roads - Include all existing roads regardless of maintenance level on the map. Identify and calculate the miles of existing roads that are still open and are under maintenance levels **three and four**. Determine through photo interpretation and/or field investigation the miles of maintenance level 1 and 2 roads that are a sediment source. Multiply miles of erosion source roads under all levels by 9 acres per mile to get acres of existing erosion. The 9 acres per mile takes into account the acres of land in rock pits, the miles of road bed, and the amount of road right-of-way.
- (3) Add a(1) and a(2) and calculate what percentage of the entire sub-basin or watershed compartment occupied by these two area

sources make up.

b. Point sources

- (1) Identify landslides from the GIS soil inventory, landform inventory, or integrated resource inventory (and those that can be identified by the most recent aerial photography). This data can also be obtained from the watershed protocol for determining landslides.
- (2) Count the number of slides that are greater than 1/2 acre in size, that are not more than 50 percent vegetated, and that terminate directly into a Class I, II, or III stream or associated stream buffer or that start in Class III streams. **Landslides starting in Class III streams must meet acreage and vegetation requirements in order to be counted.**
- (3) Calculate the number of landslides in each sub-basin or watershed compartment on a per-square-mile (mi^2) basis.

c. Linear sources

- (1) Linear sources are Class III streams within the MMI 3 and 4 areas in each sub-basin or watershed compartment.
- (2) Calculate the square miles of MMI 3 and 4 in each sub-basin. Determine what percentage this is of the total square miles (mi^2) sub-basin or watershed compartment.
- (3) Calculate the total miles of Class III streams within the MMI 3 and 4 areas and record it as the miles/ mi^2 of MMI 3 and 4 in the sub-basin. This is done by measuring miles of Class III streams in MMI 3 and 4 areas and dividing these miles by the square miles of MMI 3 and 4 areas in the sub-basin or watershed compartment.

Example:

- The sub-basin is 4.5 mi^2 ;
- the MMI 3 and 4 areas are 0.75 mi^2 ;
- the MI 3 and 4 areas represent 16 percent of the area of the sub-basin;
- and miles of Class III streams in the MMI 3 and 4 areas is 2.6 miles.
- Therefore, 2.6 miles of Class III streams divided by 0.75 mi^2 of 3 and 4 acreage in the sub-basin, give a drainage density of $3.46 \text{ mi}/\text{mi}^2$ Class III streams as the linear source of existing erosion.

- d. Sediment delivery within sub-basins or watershed compartments:.
Use the area, point, and linear source calculations with Modified Table 6 to determine the class of existing erosion for sediment delivery potential within each sub-basin or watershed compartment (Appendix A-2). Use the highest sources out of the three sources calculated to determine the existing erosion class.

Example

If all three or just two sources are present and all of them are in the same class, then that is the existing erosion sediment delivery class.

If two sources fall into one class and the third into another class, then the class with the two sources represents the existing erosion sediment delivery class.

If only two sources are measured (usually point and linear) and each falls into a different class, then the highest class is selected to represent the existing erosion sediment delivery class.

3. Component Two - sediment throughput (routing)

Use Modified Table 9 to determine the sediment throughput class for each sub-basin or watershed compartment (Appendix A-5). These classes can be determined for all sub-basins or watershed compartments in the watershed at one time. A separate overlay map of channel types should be used to mark the different throughput classes. **The ratio is figured by always dividing the miles of depositional streams by the miles of transport streams.**

- a. To determine the ratio of miles of depositional streams to the miles of transport streams for the classes in Table 9 Sediment Throughput Classes, use the following channels as grouped below.

Depositional streams

- ES1 - ES4, ES8 and PA1 - PA5, low gradient channels (<1.5%).
- FP1 - FP5, low gradient channels (<2%).

Partial Depositional and Transport Streams

- AF1, AF2, AF8, LC1, MM1, and MM2, channel gradients (2-6%).

Note: When figuring miles for this channel type; count one half the miles as transport and one half the miles as depositional.

Transport Streams

- HC1 - HC9, MC1, MC2, MC3, and LC2

Ratio of depositional to transport streams.

<u>Ratio</u>	<u>Subjective Rating</u>
$R > 3$	Very High
$1.7 < R \leq 3$	High
$0.58 \leq R \leq 1.7$	Moderate
$0.33 \leq R < 0.58$	Low
$R < 0.33$	Very Low

4. Sediment transfer hazard class

Determine the sediment delivery hazard for the existing erosion class for a specific sub-basin or watershed compartment by linking the existing erosion class (Appendix A-3) to the sediment throughput overlay map using the matrix in Appendix A-7

For example, if a sub-basin or watershed compartment has a very high level of existing erosion input (H) and a very low sediment throughput (Class I), then the sediment transfer hazard is moderate.

5. Component Three - Determination of potential fish habitat sediment hazard

- a. This hazard determination is obtained from the matrix in modified Figure 6 (Appendix A-8).
- b. The first step is to determine the sediment transfer hazard from the existing erosion process.
- c. Using a GIS program or other method for measuring miles of streams, determine the ratio of Class I and II stream miles to Class III stream miles that are affected or appear to be affected by existing linear, area, and point erosion sources. The Class I and II stream mileage is always divided by the mile of Class III streams to obtain the ratio. Class of stream ratios are given in modified Table 10, Appendix A-6. The stream mileage ratio is recorded on the "Y" axis of the sediment transfer hazard matrix in Appendix A-7.
- d. The following gives examples for a sub-basin or watershed compartment with just existing linear, point, or area erosion sources.
 - (1) Class III streams identified as existing linear erosion source. The stream distance is measured from where the Class III starts within or enters a MMI 3 or 4 area until it empties into a Class I or II

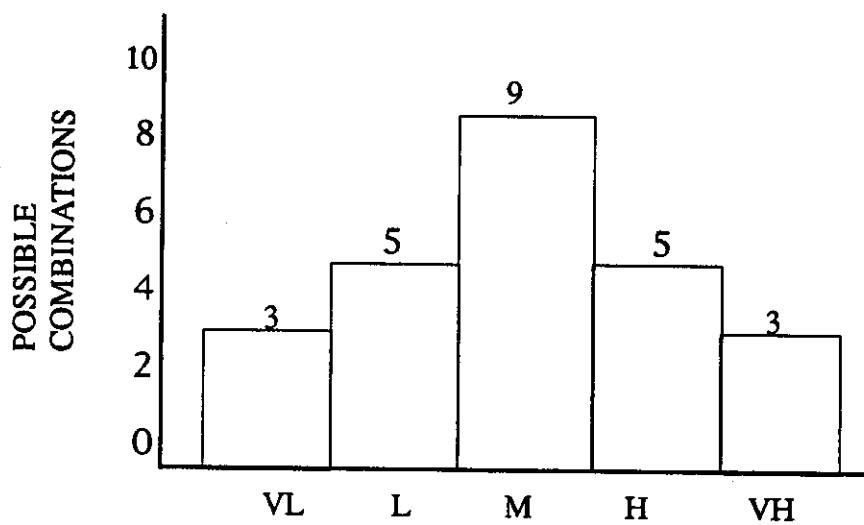
stream. Point and area erosion sources impacting a Class III stream that are within or below a MMI 3 or 4 area are included as part of the Class III linear erosion source measured distance. If the point or area erosion source is above a MMI 3 or 4 and impacts the Class III stream, the Class III stream measure for distance starts from either the point or area source and continues through the MMI 3 or 4 area until it empties into a Class I or II stream.

- (2) Class I and II streams that do not have an existing erosion source from Class III channels emptying into them are measured from any point or area erosion source impacting them.
6. On modified Figure 6, Appendix A-6, find the correct sediment transfer hazard for the sub-basin or watershed compartment on the "Y" axis and the ratio on the "X" axis. Find where the two meet with connecting lines and record the potential fish habitat sediment hazard for the sub-basin or watershed compartment and the mainstem Class I to the mouth of the next major sub-basin or watershed compartment drainage flowing into the mainstem channel.

An arithmetic relationship has been developed between the sediment transfer hazard (STH), and the Class I and II to Class III stream ratio, giving the two metrics equal weights in the determination of the potential fish habitat sediment hazard (PFHSH). An assigned weight scale of 1, 2, 3, 5, 7 will be applied to the classes for the STJH and CI+CII/CIH. The weight for the STH classes is 1=very low, 2=low, 3=moderate, 5=high, and 7=very high. The weight assignments for the CI+CII/CIH classes are 1=very high, 2=high, 3=moderate, 5=low and 7=very low. When summing the two metrics, both of which range from 1 to 7, a range of 2 to 14 for the value of potential fish habitat sediment hazard is possible. This allows for the numerical classes to be converted into a verbal (alphanumeric) rating as follows.

PFHSH	Possible Combinations	PFHSH Rating
2	1	Very Low
3	2	Very Low
4	3	Low
5	2	Low
6	3	Moderate
7	2	Moderate
8	4	Moderate
9	2	High
10	3	High
12	2	Very High
14	1	Very High

The following histogram shows the distribution of the potential fish habitat sediment hazard classes.



7. The mainstem Class I fish habitat hazard is determined by starting in the uppermost headwater sub-basin or watershed compartment. Each sub-basin or watershed compartment in order, (down stream from the first sub-basin or watershed compartment) determines the sediment hazard for the remaining distance of the mainstem Class I stream to its mouth. Examples are given below to explain this process.

If the first sub-basin or watershed compartment at the head of the watershed is rated low and all the other sub-basins or watershed compartments are very low, then the entire length of the mainstem Class I stream is rated low.

If the first sub-basin or watershed compartment is low, the second one rated moderate, and the remaining sub-basins or watershed compartments rated high, then the mainstem Class I channel is rated low to the mouth of the low-rated sub-basin or watershed compartment. From the mouth of the low-rated sub-basin or watershed compartment to the mouth of the moderate-rated sub-basin or watershed compartment, the Class I stream is rated moderate. Downstream from this point of the sub-basin or watershed compartment is rated high. The mainstem Class I stream would then be rated high to its mouth, regardless of any lower rated sub-basins or watershed compartments flowing into the Class I stream.

8. Impacts to sensitive fisheries areas.

Combine data and/or delivery class information from each sub-basin (e.g., sub-basin 1 + 2 + 3) to determine impacts to Class I streams with anadromous and resident fisheries habitat identified on key fisheries map. Sediment entering any channel may be transferred downstream to Class I stream reaches if there is not a sediment sink such as a low value fish Class 1 or 2 sediment throughput channel between the sediment source and the high value Class I fish habitat. If there is not a "sink", a "red flag" situation is indicated, because the fisheries-sensitive area is directly connected to a more efficient channel transport segment.

9. Effects And data presentation

- a. Maps

Using data for watershed sub-basins or watershed compartments, show watershed, sub-basins or watershed compartment boundaries: Class I, II, and III streams; channel types; MMI 1, 2, 3, and 4; existing harvested units and roads with maintenance levels; proposed harvest units and roads; harvest unit numbers (both existing and proposed); and road numbers (both existing and proposed).

- b. Tables

Existing erosion will be documented in a table similar to the following.

Table X - Sediment Delivery and Impacts Within Sub-basins or Watershed Compartments: Existing Erosion.

Watersheds - Upper Traitors (C59B, C60C, 000Z)

1	2	3	4	5	6	7	8	9	10	11
Column 1 -	Sub-basin Numbers									
Column 2 -	<u>Total Watershed Area</u> Acres Mi ²									
Column 3 -	Percent Sub-basin area of total watershed area.									
Column 4 -	<u>Linear Sources</u> <u>Class III in MMI 3 & 4</u> MMI Mi ² Class III mi/mi ² MMI 3 & 4 3 & 4									
Column 5 -	Area Sources <u>Existing Erosion Acres</u> Harvest & Roads Units									
Column 6 -	% Area Sources <u>Existing Erosion of sub-basin</u> Harvest & Roads Units									
Column 7 -	<u>Point Sources</u> Number Landslides Landslides per Mi ²									
Column 8 -	Sediment Delivery Class <u>Sub-basin</u> Existing erosion Class									
Column 9 -	Sediment Throughput Class									
Column 10 -	Sediment Transfer Hazard Rating.									
Column 11 -	Potential Fish Habitat Sediment Hazard.									

Narrative

Besides the maps and table, discuss in narrative form the most critical sub-basins or watershed compartments, existing erosion and sediment delivery of sub-basins, or watershed compartments (e.g., sediment sinks within sub-basins or watershed compartments where potential sediment is transported and deposited (sinks)). Discuss for each sub-basin the effects to high value fish habitat, along with cumulative sub-basin sediment transport and deposition potential in fish habitat and impact or effects of existing sediment on fisheries resource.

Tables and Figures

Modified Table 5 - Classes for Mass-Movement Index

Symbol	Class definition
MMI-1	Low MMI - Gentle slopes with little potential for mass movement.
MMI-2	Moderate MMI - Moderately steep slopes with moderate potential for mass movement where mineral soils are poorly drained and are marine clays or blue clays. Slopes from 10 to 45 percent.
MMI-3	High MMI - Steep to very steep slopes (45-90%). Stability depends on a variable number of parameters such as slope gradient, soil material, landform shape, soil drainage, parent material, etc.
MMI-4	Very High MMI - Very steep slopes (<75%). Stability depends on a variable number of parameters such as slope gradient, soil material, landform shape, soil drainage, parent material, etc.

1. MMI derived from Ketchikan Area's Mass-Movement Index Rating System.

Modified Table 6 - Sediment Delivery Within Sub-basins or Watershed Compartments:
Existing Erosion.¹

Symbol	Class Definition
VL	<p>Very low levels of sediment input from the hillslopes or terrain unit. Only stream bed and stream banks contributing minimal sediment to the stream.</p> <ul style="list-style-type: none"> -Area sources: 0 to $\leq 1\%$ -Linear sources: drainage density ≤ 0.5 mi/mi² -Point sources: 0 per mi² (historic only)
L	<p>Low levels of sediment input from one or more of the following contributions:</p> <ul style="list-style-type: none"> -Area sources: 1.1 to 1.5% -Linear sources: drainage density 0.51 to 2.0 mi/mi² -Point sources: 0.1 to 0.2 per mi²
M	<p>Medium levels of sediment input from one or more of the following contributions:</p> <ul style="list-style-type: none"> -Area sources: 1.6 to 3.0% -Linear sources: density 2.1 to 4.0 mi/mi² -Point sources: 0.21 to 0.4 per mi²
H	<p>High levels of sediment input from one or more of the following contributions:</p> <ul style="list-style-type: none"> -Area sources: 3.1 to 4.5% -Linear sources; density 4.1 to 6.0 mi/mi² -Point sources; 0.41 to 0.6 per mi²
VH	<p>Very high levels of sediment input from one or more of the following contributions:</p> <ul style="list-style-type: none"> -Area sources; $> 4.5\%$ -Linear sources; density > 6.0 mi/mi² -Point sources; > 0.6 per mi²

1. Modified Table from D. L. Hogan and D. J. Wilford. 1989. Proceedings of Watershed '89. 13p.

Modified Table 7 - Sediment Delivery Within Sub-basins or Watershed Compartments: Potential Erosion.¹

Symbol	Class Definition
I	Very low levels of potential surface erosion or hillslope instability. Expansive low relief. No MMI 3 or 4 landslide class exists in the sub-basin. Terrain effectively stores sediment so that delivery to the stream channel is disconnected. Sediment delivery from terrain units is not important.
II	Low levels of potential erosion. Mountain or hillslope MMI 3 & 4 - 1 to 20% total area of sub-basin. Low relief terrain less extensive than in Class I. Less than 2.0 mi/mi ² Class III (HCs, GO5, AF8) drainage density within MMI 3 and 4 areas for intercept of natural landslides and management activities for sediment transport.
III	Medium levels of potential erosion. Mountain or hillslope MMI 3 & 4 - 21-40% total area of sub-basin. 2.1-4.0 mi/mi ² Class III (HCs, GO5, AF8) drainage density within MMI 3 & 4 areas for intercept of natural landslides and management activities for sediment transport.
IV	High levels of potential erosion. Mountain or hillslope MMI 3 & 4 - 41-60% total area of sub-basin. 4.1-6.0 mi/mi ² Class III (HCs, GO5, AF8) drainage density per area of MMI 3 & 4 for intercept of natural landslide and management activities for sediment transport.
V	Very high levels of potential erosion. Mountain or hillslope MMI 3 & 4 - >60% total area of sub-basin. Greater than 6.0 mi/mi ² Class III (HCs, GO5, AF8) drainage density per area of MMI 3 & 4 for intercept of landslide and management activities for sediment transport.

1. Modified Table from D. L. Hogan and D. J. Wilford. 1989. Proceedings of Watershed '89. 13p.

Table 8 - Sediment Delivery from Individual Potential Erosion Sub-basins or Watershed Compartments¹

Symbol	Class Definition
I	Very low levels of sediment delivery: Roads are not parallel to streams and if parallel, they are protected by riparian management areas. Harvest units do not boarder streams and have no streams within their boundaries. If units border streams or have streams within their boundaries, the streams(s) are protected by a riparian management area. Sediment delivery from this terrain and management units is not significant.
II	Low levels of sediment delivery: Combined area of harvest units and roads on MMI 3 and 4 soils and slopes is equal to or less than 20 percent of the MMI 3 and 4 areas of the sub-basin. Harvest units that border streams or have streams within their boundaries are protected by a riparian management area. Roads parallel to streams are protected by a riparian management area. Only low amounts of the potential sediment eroded from management activities with this terrain will reach the channels.
III	Medium levels of sediment delivery: Combined area of harvest units and roads on MMI 3 and 4 soils and slopes is equal to or greater than 21 percent but not greater than 40 percent of the MMI 3 and 4 areas of the sub-basin. Harvest units that boarder a stream or have streams within their boundaries (except for green and white) and orange and white flagged Class III streams are protected riparian management areas. Roads that are parallel to streams (except to Class III streams) are protected by a riparian management area. The above features will transfer medium amounts of the potentially eroded sediment to the channels.
IV	High levels of sediment delivery: Combined areas of harvest units and roads on MMI 3 and 4 soils and slopes is equal to or greater than 41 percent but not greater than 60 percent of the MMI 3 and 4 areas of the sub-basin. Class III streams make up 50-75 percent of all streams associated with harvest units and roads. Roads parallel to streams (except for Class III streams) have the streams protected by riparian management areas. These terrain features will deliver much of the potential mass movement and road erosion sediment to channels.
V	Very high levels of sediment delivery: Combined areas of harvest units and roads on MMI 3 and 4 soils and slopes is greater than 60 percent of the MMI 3 and 4 areas of the sub-basin. Roads parallel to streams are protected by riparian management areas. Sediment resulting from any mass-movement events will directly impact channels. These terrain features will deliver most of the road erosion sediment to channels.

1. Modified Table from D. L. Hogan and D. J. Wilford. 1989. Proceedings of Watershed '89. 13p.

Modified Table 9 - Sediment Throughput Classes¹

Class	Description
1	The ratio of miles of depositional streams to miles of transport streams is $R > 3$
2	The ratio of miles of depositional streams to miles of transport streams is $1.7 < R \leq 3$
3	The ratio of miles of depositional streams to miles of transport streams is $0.58 \leq R \leq 1.7$
4	The ratio of miles of depositional streams to miles of transport streams is $0.33 \leq R < 0.58$
5	The ratio of miles of depositional streams to miles of transport streams is $R < 0.33$

1. Modified Table from D. L. Hogan and D. J. Wilford. 1989. Proceedings of Watershed '89. 13p.

Modified Table 10 - Ratio of Class I and II Streams to Class III Streams¹

Class	Description
1	The ratio of miles of Class I and II streams to miles of Class III streams is $R > 3$
2	The ratio of miles of Class I and II streams to miles of Class III streams is $1.7 < R \leq 3$
3	The ratio of miles of Class I and II streams to miles of Class III streams is $0.58 \leq R \leq 1.7$
4	The ratio of miles of Class I and II streams to miles of Class III streams is $0.33 \leq R < 0.58$
5	The ratio of miles of Class I and II streams to miles of Class III streams is $R < 0.33$

1. W. David Loggy, 1994.

Modified Figure 5 - Sediment Transfer Hazard Matrix

Modified Figure 5. - Sediment transfer hazard matrix

Sediment Throughput Class

Sediment Delivery Class

VL-I

L-II

M-III

H-IV

VH-V

1
R>3

2
1.7<R≤3

3
0.58≤R≤1.7

4
0.33≤R<0.58

5
R<0.33

2

4

6

8

10

12

14

16

18

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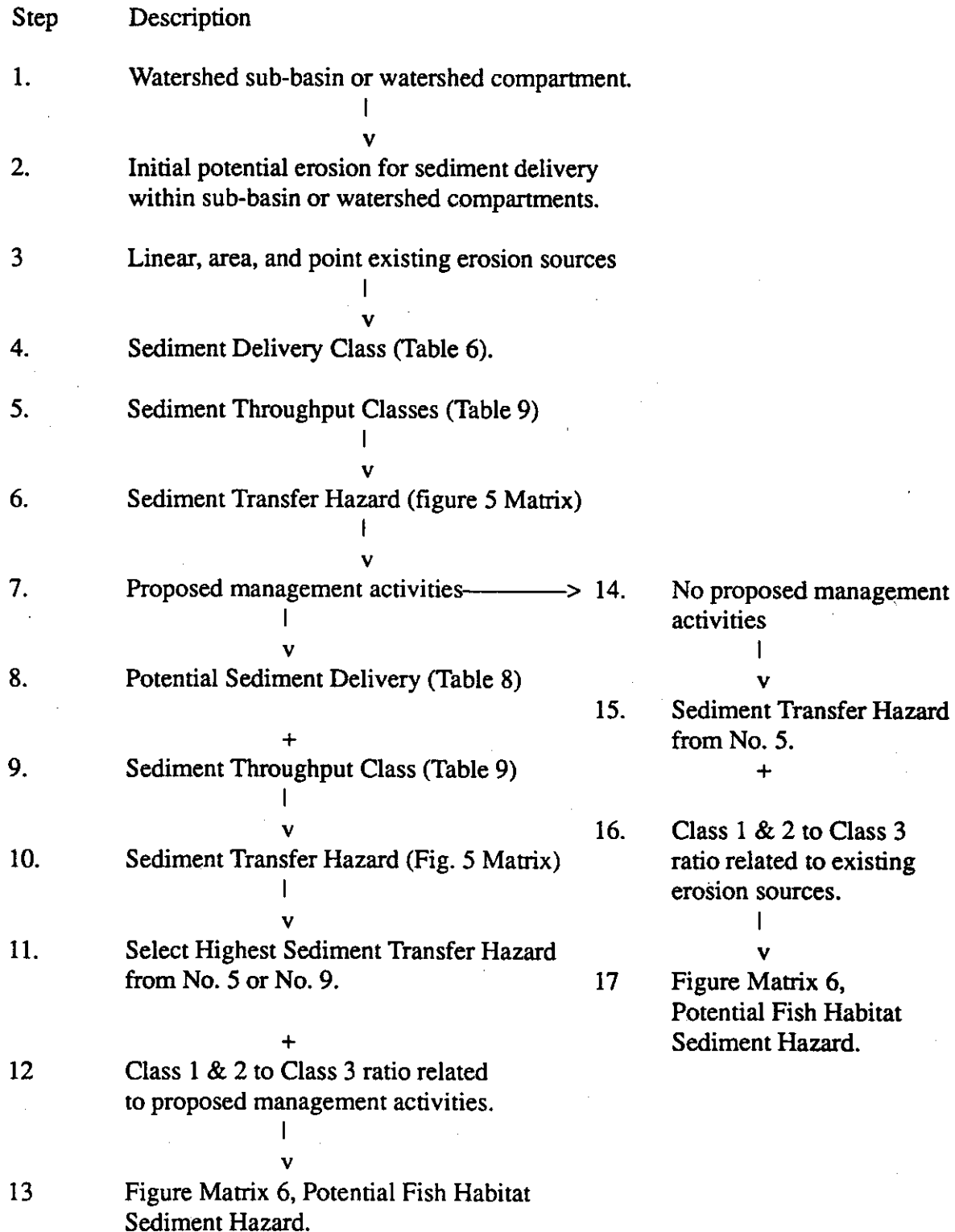
D.L. Hogan and D.J. Wilford. 1989. *Proceedings of Watershed 1989*, 13p.

Modified Figure 6. - Potential Fish Habitat Sediment Hazard

sub-basin Sediment Transfer Hazard	--Ratio of Class I and II Streams to Miles of Class III Streams--									
	R>3		1.7<R≤3		0.58≤R≤1.7		0.33≤R<0.58		R<0.33	
	1-VH		2-H		3-M		4-L		5-VL	
	3	2.4	1.7	1.0	0.62	0.44	0.33			
1-VL	2	+	3	**	+	4	**	6	+	8
			**			**				**
	Very Low		**			**				**
2-L	+	3	**	+	4	+	5	**	+	7
	**				**				**	9
			Low		**				**	
3-M	+	4	+	5	**	+	6	+	8	**
			**					**		10
			**	Moderate			**			**
4-H	+	6	+	7	+	8	**	+	10	+
				**		**			**	12
+				**			High		**	
5-VL	+	8	**	+	9	+	10	+	**	12
						**			**	14
								Very High		
	+	+	+	+	+	**	+	+	+	+

W. Loggy. 1994.

Modified Figure 7 - Flow Chart of Sediment Transfer Hazard Classification System



Literature Cited

- Marion, D.A. 1988. Final Watershed Boundary Delineation Procedure and Numbering Rules." Internal paper. Sitka, AK: Tongass National Forest, Chatham Area.
- USDA Forest Service. "Watershed Planning." Forest Service Manual 2510.
- USDA Forest Service. "Watershed Coding." Forest Service Manual 2513.2, Interim Directive No. 1.
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Appendix 4.3
Channel Type Verification Protocol
for the
Region 10 Watershed Analysis

Revised 1994

Region 10 Watershed Analysis

Adapted from original procedures in the R10 handbook

Channel Type Verification Protocol

25 -Field Verification

Field verification requires the field sampling of representative areas of a given channel type segment. The primary purpose of field verification is to determine if the channel type mapping, based on aerial photographic interpretation, is accurate. The secondary purpose of field verification is to characterize key physical features associated with the various channel types measured in the field in order to better define the channel type classification units.

25.1 Site selection.

All verification sampling is performed using representative sites to characterize the physical properties of an entire channel type segment (hereafter referred to as "segment"). The term "site" refers to a short channel area which is a representative subset of the entire segment, and which is used as the sampling unit. The representative sample site is a channel area which has physical features that occur most frequently for the segment being sampled. These features, which are present or absent within the segment as a whole, have the same occurrence frequency in the site. The predominant range in physical dimensions that occurs for key features throughout the segment also occurs in a similar manner within the site. This site also demonstrates the sample spatial patterns of features which occur over the entire segment. The site is not necessarily uniform in its physical characteristics. Rather, the variation in these characteristics occurs in an amount and pattern similar to that of the entire segment.

Only after site representativeness has been confirmed, does sampling begin. Site representativeness is first assessed by selecting "potential" sampling sites in the office prior to field work. In the field, each potential site is assessed by conducting a brief ground survey along several hundred yards of the segment to determine how well the potential site represents the segment. Sites which have been extensively disturbed by road construction, mining, recreation, or other developments are not to be sampled. Sites that are to be sampled which occur downstream of such developments should be noted as such on the data card.

The length of each sample site should be; (1) two pool/riffle sequences; (2) ten times the channel bankfull; or (3) 330 feet, whichever is least, but in no case should the sample length be less than 100 feet. Sampling should occur at low flow stage, which is one-third or less of the bankfull stage.

25.2 Methods

25.2.a. Equipment. The following equipment is required for the verification field work:

- 1) Watershed field map
- 2) Aerial photographs
- 3) Permanent ink marking pen
- 4) Verification data card
- 5) Data card key
- 6) Canopy type key
- 7) Notebook with Rite-n-rain paper
- 8) Flagging
- 9) 100-foot tape measure
- 10) 6-foot tape measure (optional)
- 11) Hand level or transit
- 12) 35 mm camera and film
- 13) Clinometer
- 14) Stadia rod
- 15) Range finder
- 16) Headset radios, 2 per team (optional)

25.2.b. Data collection. The following data entries and data collection methods are to be used at each sample site. They are listed in the order of their appearance on the channel type verification data card (Figure 1). When taking measurements, the right bank is the bank on the observer's right side when facing downstream.

- 1) **Date:** Record as a six-digit number using a year-month-day format.
- 2) **VCU:** Record the three-digit VCU number.
- 3) **Segment:** Record the three-digit number.
- 4) **Site:** Record the four-digit number. (Unique within a watershed and assigned by the field crew at the time of sampling)
- 5) **Ranger District:** Record the ranger district DG address.

Stikine Area Tongass National Forest

Petersburg Ranger District - F02D01

Wrangell Ranger District - F02D02

Chatham Area Tongass National Forest

Sitka Ranger District - F03D01

Hoonah Ranger District - F03D02

Juneau Ranger District - F03D03

Yakutat Ranger District - F03D04

Admiralty National Monument - F03D05

Ketchikan Area Tongass National Forest

Craig Ranger District - F05D01

Appendix 4.3 - Channel Type Verification Protocol

Ketchikan Ranger District - F05D02
Thorne Bay Ranger District - F05D04
Misty Fiords National Monument - F05D05

Chugach National Forest

Glacier Ranger District - F04D01
Cordova Ranger District - F04D02
Seward Ranger District - F04D03

- 6) Management area: Record the standard three character Forest LMP management area label.
- 7) Subsection: Record the two digit subsection number (from the watershed field map).
- 8) Quarter-quadrangle: Record the name of the USGS quarter-quadrangle which covers the sample site. The name should be the same as that at the bottom right hand side of the USGS quad. For example, Petersburg (C-3). If a quarter-quadrangle is used, identify which fraction (NW, SW, NE, SE) is used.
- 9) Stream name: Record the stream name for the drainage basin containing the sample site. If the stream is unnamed, then enter "unnamed".
- 10) ADF&G number: Record the ADF&G Anadromous Stream Catalog number.
- 11) Crew: Record the initials of the field crew. The person recording the data on the verification card should write his/her initials first.
- 12) Aerial photograph: Record the year, flight line number, roll number, and photo number of the aerial photograph covering the site. The flight year is the last two digits of the year (1984 = 84). The line number is an alphanumeric three character label. The roll and photo numbers are three and four digit numbers, respectively. Insert leading zeros where less than three or four digits occur.
- 13) Camera photos:
 - a) Film type: Circle whether the film is slide or print.
 - b) Upstream/downstream roll and photo numbers: Record the three-digit upstream and downstream film roll number. To establish the roll number take one or two pictures of a sheet of paper with the roll identification number spelled on it. The roll identification number is increased sequentially for each new roll of film.

Region 10 Watershed Analysis

Record, in the appropriate space, the two digit number of the upstream and downstream sample site photographs taken. The number is taken from the camera counter.

Suggested Procedure

Use the PHOTO LOG card (see Figure 2) to record all camera photographs for a given roll.

Camera: Record the name of the person responsible for the camera.

Slides/Prints: Circle appropriate film type.

24Exp/36Exp: Circle the appropriate number of exposures for the roll used.

Roll: Record the number assigned to the roll.

Film: Circle whether the film is 35mm or 110mm.

Date started: Record the date the first exposure was shot on the roll.

Date finished: Record the date the last exposure was shot on the roll.

ASA: Record the ASA speed for the film used.

Photo: Record the subject of each photograph taken opposite the appropriate photo number. Use the camera counter to determine the photo number.

- 14) **Preliminary channel type:** Record the channel type assigned during premapping to the segment being sampled (taken from the aerial photo).
- 15) **Final channel type:** Record the final channel type (determined after field verification and final correlation).
- 16) **Adjacent landform:** Record the predominant landform for both the left and right banks over a minimum of 10 acres (except as noted below). If more than one distinct landform occurs along the site bank, record the landform occupying the greatest length of the site. Landforms are delineated using the R-10 Landform Legend. In the office, they are determined from the aerial photograph with the mapping box containing the site. To determine the 10-acre size on an aerial photo, consider an area contained within an imaginary rectangle in which the channel is one of the short sides and one of the long sides extends away from the channel a distance sufficient to contain 10 acres (0.25 inch by 1.0-inch area on 1:15,840 aerial photos). Landforms are verified in the field by observing landform slope, relief, dissection, and landscape position characteristics.

The only exception to the 10-acre minimum size rule is when an alluvial floodplain or river terrace occurs directly adjacent to the channel. If the floodplain or river terrace averages greater than 30 feet (10 meters) in width, and is continuous along the bank, then record the respective landform as a floodplain. If the floodplain or river terrace is discontinuous or averages less than 30 feet in width along the bank, note its presence in the COMMENTS, but ignore its presence for landform identification, and consider the 10-acre area extending above the floodplain or river terrace.

17) **Plant association and vegetation**

Record the predominant riparian vegetation cover types for both the left and right banks over a minimum of 5 acres. Record overstory, understory, and successional stage codes for each dominant cover type in the sample reach. If more than one distinct cover type occurs along a site, record the type occupying the greatest length of the site. Riparian vegetation codes are as follows:

Coding system for riparian inventory projects
(CT Verification, Basin-Wide Survey, etc.)

a) **Forest vegetation** (at least 10 percent cover of trees at least 25 ft. tall)
Dominant overstory type (forest series)

100	Western hemlock
200	Western hemlock-yellow-cedar
300	Sitka spruce
390	Sitka spruce-mountain hemlock (high elev.)
400	Mixed conifer (mtn. hemlock, cedar, others)
500	Mountain hemlock
600	Shore pine
700	Red cedar
800	Cottonwood or cottonwood-spruce
900	Fir (subalpine or silver)
000	Undetermined forest type

Nonforest or no vegetation

1000

b) **Understory codes**

10	Shrub-dominated (species not determined, mixed type [no one species dominant] or dominated by species not listed below)
11	Alder
12	Blueberry
13	Devil's club

- 14 Red-osier dogwood
- 15 Salmonberry
- 16 Stink currant
- 17 Willow
- 18 Peatland subshrubs (crowberry, bog laurel, Lab. tea)
- 19 Alpine subshrubs (cassiope, mountain heather)
- 20 Forb-dominated
- 21 Skunk cabbage
- 30 Fern-dominated
- 40 Graminoid-dominated
- 41 Grass-dominated
- 42 Sedge-dominated
- 50 Bryophyte-dominated (moss or liverwort)
- 51 Sphagnum
- 80 Unvegetated
- 81 Bedrock
- 82 Surficial deposits
- 83 Organic debris (recent clearcut, logjam, etc.)
- 84 Ice/snow
- 85 Other

c) **Seral stage coding**

- 0 Nonforest: does not apply
- 1 Early successional: graminoid-forb, e.g., meadow
- 2 Shrub-seedling, e.g., brushfield
- 3 Sapling-pole young forest (early second growth), e.g., doghair stands, little understory
- 4 Young saw timber (even-aged, >9" DBH [23 cm])
- 5 Mature stand
- 6 Old growth (multiple canopy heights and tree diameters, > 150 years old, developed understory)

18) **Site disturbed:** Record whether the site has been disturbed by management activities or catastrophic natural processes. YES is circled if a site has one or more of the following characteristics:

- a) Any obvious tree felling (selection cutting or clearcutting) has occurred within 100 feet on at least one side of the channel, either immediately adjacent to or immediately upstream of the site.
- b) More than 25 percent of the upstream basin area is covered by second-growth vegetation less than 30 years old. For old clearcut areas (30+years), use new vegetation codes 95 and 99. See the plant association code documents.
- c) Blowdown or mass erosion affects more than 30 percent of the entire

segment. Upper bank sliding and debris torrents in headwater or tributary channels also qualify as site disturbance and should be noted.

If YES is circled, note in the COMMENTS what type of disturbance occurs.

- 19) **Sideslope length and angle:** Not applicable
- 20) **Stream gradient:** Record the stream gradient and identify the method used to determine it. Gradient is measured over at least two pool/riffle (or glide/riffle) sequences. Normally measure from pool to pool, and be certain to measure between the same relative locations (foot of pool to foot of pool, etc.). Use one of the following methods:
 - a) **Clinometer:** This method is only adequate on high gradient channels and is done by a single person using a stadia rod and a clinometer. First, measure eye height by standing straight on level ground, holding the rod close and directly in front of one's body. Next, stand at the water's edge in an area of overhanging vegetation and mark eye height on some of this vegetation by holding the rod vertical at the water's edge and flagging where this elevation occurs on the vegetation. Then, walk the distance over which the gradient is to be measured and again stand at the water's edge and measure gradient by sighting on the flagging while standing straight. Record this gradient to the nearest 0.5 percent.
 - b) **Clinometer with rod:** This is performed with two persons using a clinometer or hand level and one stadia rod. First, measure the eye height of the person doing the sighting and mark this height on the rod with some flagging. The rod person holds the rod vertical with the bottom of the rod at the water surface, while the sighting person walks the distance over which the gradient is to be measured. The sighting person, while standing at the water's edge, measures the slope by sighting on the flagging, which is held perpendicular to the rod by the rod person. The gradient is recorded to the nearest 0.5 percent.
 - c) **Head drop (HD):** This is done by two people using a clinometer or hand level and a stadia rod. First, measure the sighting person's eye height. The rod person then measures off the distance (with either a tape or range finder) over which the gradient is to be determined. The rod is held vertical at the water's edge with the bottom touching the water's surface. The first person then sights a level line and notes the elevation of the level line on the rod. The difference between the first person's eye height and the elevation on the rod is the head drop. The stream gradient is calculated by dividing the head drop by the distance. This number is recorded to the nearest 0.5 percent.

- 21) **Incision depth:** Circle the appropriate incision depth class separately for each bank. The incision depth is the vertical distance between the first discernible slope break above bankfull stage and the channel bottom at the thalweg point. In entrenched channels, the streambank and the valley wall may coincide. The bank area used to measure incision depth should be representative of the predominant situation occurring on both banks throughout the site.
- 22) **Substrate:** Conduct a 50-sample boot tip cross channel or zigzag transect that considers both the lower bank and bed in proportion to their respective area coverages. Locate the transect on one or more representative riffle sections within the same 2 pool/riffle sequence as used in the stream gradient determination. Tally the substrate size classes opposite their respective names. Calculate the percentages across from the appropriate size class name and enter as a whole number. Also, total the percentages to check for possible calculations errors. An error of plus or minus 2 percent is acceptable.

Use the following substrate categories which are broader groupings of the American Geophysical Union grade scale as published in the Handbook of Applied Hydrology by Ven Te Chow, 1964 (p. 17-14).

<u>SIZE</u>	<u>CLASS</u>
> 3 FT.	Bedrock
10 to 36 in.	Small Boulders
5 to 10 in.	Large Cobbles
2.5 to 5 in.	Small cobbles
1.0 to 2.5 in.	Coarse gravel
4 mm to 1.0 in.	Fine gravel
< 4mm	Very fine gravel or sand Organic muck

- 23) **Channel pattern:** Record the relative proportion of channel patterns occurring over the entire sampling site length. The total percentage of segment length having a given pattern is recorded to the nearest 10 percent. The channel patterns are defined as:
- a) **Single:** Channels having one single channelway with a single thalweg that generally parallels the banks. Side channels or overflow areas cover less than 10 percent of the site bankfull width.
 - b) **Multiple:** Channels having more than one channelway or flow path occurring within the bankfull area which cover greater than 10 percent of

the site bankfull width. These channels still have a single thalweg over most of their length, but the thalweg often has shorter meander wavelengths than the bankfull channel meander wavelength.

- c) **Braided:** Channels having numerous flowpaths, discontinuous thalweg, and extensive bar and riffle development.
- 24) **Bank control:** Circle the streambank composition which best typifies the entire segment. The three types of bank control are:
- a) **Bedrock:** Channels contained within rock walls or with extensive outcropping along the banks and bed (greater than 15 percent of the channel length).
 - b) **Mixed:** Channels contained within a mixture of colluvial, alluvial, and bedrock materials with consistent, but not extensive, bedrock occurrence within the banks or bed (2-15 percent of the channel length).
 - c) **Alluvium:** Channels cut into alluvium with very infrequent bedrock occurrence in the banks and bed (less than two percent of the channel length).
- 25) **Stream geometry:** Stream geometry measurements are taken along a cross-section that is located in a straight channel segment and is representative of the streams average width and depth within the sampling reach. Locate the cross-section away from local constrictions such as large woody debris accumulations, bedrock constrictions, or large boulder accumulations. If the above conditions cannot be met, notes to that effect should be recorded in the comment section.

Distinctive high water marks such as consistent exposures or raw bank material, significant breaks in slope on the banks, and change from presence to absence of hydrophytic or disturbance vegetation are used to distinguish the mean annual high water level.

For the following data entries refer to the appropriate section on the channel type verification card:

- a) **Bankfull width and depth.** Record the bankfull width and depth. Bankfull width and depth are measured using a 100-ft. tape and a stadia rod as follows:
 - (1) Secure the 100-ft. tape the bank beyond the bankfull edge and stretched perpendicular to the banks (not the active stream) across the channel. Secure to the opposite bank at the same elevation as on the first bank. Pull the tape taut to remove as much sag as possible.

On wide channels (>80ft), a hand level, stadia rod, and range finder may be used to get more precise depth measurements.

(2) Holding the rod vertical at the bankfull edge of one bank, the distance at the intersection of the rod with the tape is recorded under BankFull, opposite DISTANCE. The same technique is repeated on the opposite bank. The difference between the two distances is the bankfull width.

(3) The intermediate sampling interval distances along the cross-section for measuring bankfull depths is determined by dividing the bankfull width by five. This number represents the distance between each intermediate bankfull depth measurement station.

Starting at one side, the observer moves to either the lower bank, thalweg, or the intermediate distance (determined by adding the value established in step 3 to the bankfull edge measurement) to the first depth sampling station, whichever is closer to the starting point. The elevation between the channel bed and the tape is determined by holding the rod vertical to the channel bottom with the bottom resting on the bed and noting the elevation where the rod intersects the tape. The distance is measured directly from the tape at this intersection of rod and tape. The measurements are entered directly on to the form in the first blank column opposite DISTANCE and DEPTH. This step is repeated as the observer progressively moves across the channel to the other side.

- b) **Active area.** The active area is that portion of the channel which contains water at the time of sampling. Active width and depth numbers are recorded opposite the ACTIVE notation on the data card. They are taken at the cross-section used for the bankfull area measurements. Measurements are performed as follows:

(1) **Active depth:** The first active depth is determined at the first bankfull depth sampling station. If this station occurs above the water surface, an N/A is recorded opposite ACTIVE. If the station occurs within the wetted area, then the active depth is determined by holding the rod vertical with the rod bottom resting on the channel bed, and noting the elevation of the water's surface and this value recorded opposite ACTIVE. This procedure is repeated at each depth sampling station, with successive active depths being recorded in order opposite ACTIVE.

(2) **Active width:** Active width is the width of the channel which contains water at the time of sampling. It is determined at the cross-section used for the bankfull area measurements. Active width is determined by holding the rod vertical at the water's edge on one bank. The distance at the intersection of the rod with the tape is recorded. The same technique is repeated at the opposite water's edge. The difference between the two distances is the

active width. The Values are recorded opposite ACTIVE WIDTH and under START, END, and WIDTH.

Undercut Banks: Active water width should be measured from the stream bank edge and should not include any undercut stream segments. Measurements of the undercut bank should be included separately as comments. A separate data field will not be used for undercut banks.

- 26) **Fish:** If fish are observed within the sample site, record Y for "yes" under OBSVD (i.e., observed). identify the life stage as J for juvenile, A for adult, or JA if both lifestages are observed. If possible, identify and record the observed species using the following codes:

KS - king salmon	DV - Dolly Varden
SS - silver (coho) salmon	RT - rainbow trout
RS - red (sockeye) salmon	CT - cutthroat
CS - chum salmon	SM - smelt
PS - pink salmon	ST - steelhead
NP - northern pike	BT - brook trout
CO - cottids	GR - grayling
LT - lake trout	WH - whitefish
SB - stickleback	BU - burbot
UN - unknown	OT - Other

If species cannot be determined, record UN for "unknown."

If no fish are observed, record N/A under OBSVD, LIFESTAGE, and IDENTIFY.

- 28) **Transect distance:** Record the length of the sample site in feet.
- 29) **LWD tally:** The LWD tally is a transect count of all large organic debris within the bankfull width of the channel that is currently influencing the channel. The transect is conducted over the entire sample reach, and the LWD is tallied by average diameter and total length of each piece. Minimum size tallied is 4 inches by 10 feet in length unless it has a root wad attached.
- 30) **Comments:** Record any significant conditions or factors which may affect the data collected, or its interpretation. Observations to be noted include: high rainfall, rising water stage, extensive sedimentation or erosion, extensive blowdown or

Region 10 Watershed Analysis

mass erosion, presence of anadromous fish, presence of possible fish passage barriers, land use conditions other than undisturbed, glacial till exposed in banks or bed, marine sediments exposed in banks or bed.

Abbreviations for Comments Section

AG	ADF&G
S	Substrate
SP	Stream Pattern
CT	Preliminary or final Channel Type
BC	Bank Control
T	Temperature
SG	Stream Geometry
W	Weather
AP	Aerial photo or ground photo
LF	Landform
F	Fish, present or absent
C	Canopy Type
LOD	Large Organic Debris tally
PA	Plant Associations
TL	Transect Length
SS	Sideslopes (Coho salmon code also SS)
G	Gradient
N	Manning's N (roughness coefficient)
BA	Basin Area and precipitation readings
RGP	Riffle, Glide, Pool

These codes are to be circled when used in the comment section, for example: (SG) not taken due to adverse depth and flow conditions.

Appendix 4.4
Riffle Stability Index Protocol
for the
Region 10 Watershed Analysis

Draft by
Michael D. Wolanek
Hydrologist
Stikine Area
Tongass National Forest

Introduction

The Riffle Stability Index (RSI) procedure uses an analysis of streambed surface material to determine the degree of aggradation, degradation, or dynamic equilibrium of gravel/cobble stream channels. The methods employed closely follow those of RSI's developer (Kappesser 1993), and all users of RSI procedures should become familiar with his paper. The protocol below includes all of Kappesser's data elements and several additional parameters that may be of value in interpreting the results. The discussion is formatted to follow the field data collection forms provided.

Sampling Design

Header Data

Fill in all blanks. "Other I.D." and "Reach I.D." are provided to record data specific to the project in which this protocol is employed.

Riffle Particle Size Distribution

Gradient—of the riffle itself. Measure over the riffle length as given below. Indicate method. Use of a level, rod, and tape is intended, but a clinometer measurement with a rod is sufficient.

Bankfull Width—at the best cross-section on the riffle, or mean of 3 widths if uncertain.

Riffle Length—length of riffle section from riffle crest to head of pool, glide, or other flow feature. Measure with tape.

Number of transects—across the riffle, from bankfull to bankfull, that are used during a Wolman pebble count. At least 3 transects should be run—one across the middle of the riffle and one near both the top and bottom of the riffle.

Depth of flow—over the riffle. Record the mean of three or more measurements with a staff (or estimate).

Photo record—record here for riffle and point bar photographs.

Wolman pebble count (Wolman 1954)—Heel-to-toe transects across the riffle. Tally 200 times; more is OK. Tally <200 times only when time is limited. A tally of <100 times is unacceptable. Measure first particle touched by a finger when reaching off the end of a boot (no looking!). Measure the intermediate access of the selected particle using a scale in millimeters. Record in the millimeter size classes given in the table. Count total number of tallies and determine conversion to calculate the percent distribution of the bed material. Add distributions from smallest to largest size classes in the cumulative column, ensuring total is 100 percent. Each value in the cumulative classes represents the percent of material that is finer than the upper limit of that size class.

Dominant large particle size moved at bankfull discharge

Depositional feature—record the feature selected. Active bars preferred.

Freshness:—Circle or record responses for: vegetation (amount of moss and algae, etc. should usually be absent, qualitative embeddedness (fines in voids around gravels and small cobbles—less is best), and qualitative packing and armoring (loose assortment; some, or moderate with smaller size classes; or moderate or larger size classes—less is best).

Transition distance and type of flow: Measure distance from tail of the riffle sampled to the center of the depositional feature sampled. Record the flow type—glides, runs, pools, debris influenced eddies, or whatever.

Gradient and bankfull width: Measure as under Riffle Particle Size Distribution above.

Bar length and maximum width: Measure with tape from upstream to downstream points (length) and from bankfull to the bar perimeter at its widest point. Selection of these points is based on a visual survey of streambed features. Bias is expected by observer and flow condition—expected accuracy is within about 10 feet.

Depth of flow: If any, over the deepest large particle selected for measurement.

Particle size tally: Selectively sample 25 to 30 of the largest dominant particles residing on the fresh bar or depositional area. The area over which the particles are sampled is variable, but should always be downstream of the smallest radius of curvature of the bar. The surveyor should consider the entire bar surface area and not limit sampling to isolated areas within the bar. Measure the intermediate axes using a scale in millimeters. Record the actual measurement to the nearest millimeter in the blanks provided.

Tractive Force Alternative

A channel cross-section and energy gradient will be surveyed and monumented if a satisfactory depositional area is not found in a reach of interest. See Kappesser, 1993. Data to be recorded is self-explanatory. A sketch should always accompany this survey (plan and cross-section views). It is suggested that at least one cross-section survey be completed in addition to the point bar particle size tally for a comparison of results.

Quality Assurance/Quality Control

Prior to sampling each day, the crew (of at least two persons—a third person may help reduce the time required for the riffle pebble count) should somewhat randomly pick up 20 rocks and particles of various shapes (spheres, rods, disks, blades) and measure the intermediate axis. Without telling the other person, record the intermediate axis. Have the second person measure and record the intermediate axis. Determine both actual differences and changes in size class that would occur by error. Work to correct obvious errors in methodology before proceeding with actual sampling. Report collective results of this

QA/QC check when reporting project results.

Use the weatherproof graph paper provided (4-cycle semilog by 10 sq./in., and 10 sq./in. linear) to plot riffle particle size distributions and point bar size distributions, and to sketch a site map of the reach sampled. On-site processing is a quality control measure which ensures completeness and allows correction of errors.

Together, the crew will review and verify data cards for completeness and accuracy before proceeding to the next site/segment. Double-check data and calculations back in the office. Use of the RSI analysis program on the personal computer should reduce processing errors.

Literature Cited

Wolman, M.G. 1954. A method of sampling coarse river bed material. Trans. Am. Geophys. Union, 35 (6):951-956.

Kappesser, Gary B. 1993. Riffle Stability Index—A Procedure to Evaluate Stream Reach and Watershed Equilibrium. Unpublished paper, Idaho Panhandle National Forests. 10 p.

Riffle Stability Index Data Collection Equipment Needed

Neoprene gloves

With index finger and thumb removed to facilitate sampling smaller particles

Pocket metric scales (150 mm or larger)

To measure in millimeters

Tape (150 ft.)

Bankfull width; bed feature measurements

Collapsible staff

Flow depths over and gradients of bed features

Level (and/or clinometer)

Gradient of bed features

Flagging and/or Flag-pins

To mark sample locations for later reference

Monuments and supplies

If tractive force sites requiring cross-section surveys will be sampled

Camera and film

Photographic record

Clipboard

Data collection

Data Forms

Blanks

Pencils

Lots!

Riffle Stability Index Data Forms

6.5 in.

Figure RS-1. Riffle Stability Index (RSI) Field Data Collection Form

Figure RS-2. Dominant Large Particle Size Moved at Bankfull Discharge Form

Reach Data and Riffle Particle Size Distribution

Particle Size Tally and Channel Cross-section

1.5 pt.

=1.5 pt.

=1.5 pt.

1.00 in.

1.00 in.

6.5 in.

Full-sized master forms, for reproduction use, are provided in pocket at the back of the appendices.

0.5 in.

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Appendix 4.5
Macroinvertebrate Sampling Protocol
for the
Region 10 Watershed Analysis

Draft by
Michael D. Wolanek
Hydrologist
Stikine Area
Tongass National Forest
July 1994

Region 10 Watershed Analysis

Sampling Design

Macroinvertebrate Sampling Design—Influences from the literature

Milner and Oswood's (1991) draft techniques for rapid bioassessment surveys in the Anchorage, Alaska area are generally used in the procedures developed for the Kadake Creek Watershed Analysis. Consideration of the methodologies and principles presented in USDA (1985) and Standard Methods (19____) also influenced the following procedures. One deviation from Milner and Oswood's (1991) methods is the lack of random selection within selected stations. When objectives deal primarily with watershed health and not population dynamics, select microsites in riffles that meet flow and substrate characteristics preferred by many sensitive EPT species. Stations are reaches within channel type segments that include these habitats and which may (treatment) or may not (control) be affected by management activities.

Sampling Objectives

The following objectives influence sampling design.

Objective 1—Utilize macroinvertebrates as a general indicator of watershed health. Therefore, select a sampling station lower in the watershed which typically includes cobble/gravel substrate, favorable flows, and which is upstream of any tidal influence.

Objective 2—Consider the macroinvertebrate data in determining the effects of management and natural disturbances on stream health. Select sampling stations as near as possible to the disturbance, as well as control stations either upstream or in an immediately adjacent and similar stream and sub-basin. Disturbances include clearcut harvesting with no buffers (pre-TTRA units), eroding road cuts, and mass-wasting events.

Objective 3—Consider the macroinvertebrate data in determining whether subwatersheds are naturally different, or whether they contribute differentially to the results of objective 1. Select stations near the mouths of sub-basins which are significant in terms of size, geology, management influences, etc.

Station Size and Selection

Stations should meet the criteria given under "Station Selection" in Milner and Oswood (1991) and should be limited to a continuous channel-type segment. Five (5) samples will be collected from each station. When conditions/influences of/on a channel appear uniform throughout a channel-type segment (gradient, substrate size distribution, riparian stand & subsequent solar radiation, presence/absence of units, roads, or mass wasting deposits, etc.), consider the entire segment, equivalent to one station, and attempt to collect one sample from every other riffle. When non-uniform (and typical) conditions occur, professional judgement is required to delineate stations that best meet the sampling objective. It is anticipated that one sample will often need to be obtained from each consecutive riffle, especially on larger systems. Conditions may also require more than one sample obtained from the larger riffles in order to obtain five samples per station. It is necessary to collect the samples within a relatively homoge-

neous segment to minimize natural variability; yet, it is equally important to maintain sample collections in a reasonable range of distance to the potential impact or watershed setting that influenced the segment selection for monitoring.

Note that riffles/runs will be the only habitats sampled, because most species intolerant to disturbance and pollution will be found there. There may be occasions where not all samples can be collected from riffles, but the need to sample to maintain comparisons between segments still exists. In these limited instances, sampling may occur in gravels located on/near pool tails, and a note should be made on the data form. Sampling should never occur in pools themselves (certainly not without documentation; high gradient channels could require pool sampling, but no high gradient channels segments are planned for monitoring).

Sampling Methodology

Select station within channel-type segment (as described in previous section).

Work from downstream to upstream direction within each segment.

One or more crew members begin support-data collection. This includes simple channel-type verification, channel gradient, stream discharge, and substrate size distribution. Perform an "abbreviated" 25-tally Wolman Pebble Count from the station's riffles and determine the 16-, 50-, and 84-percentiles of the distribution. This distribution is then used as a standard by which to compare the substrate characteristics of each individual sample. Bankfull and active channel widths are obtained from the stream discharge measurement on larger channels and may also be obtained at each individual sample location on smaller channels. Also water quality data collection at this time. For this study, the YSI 3800 will be used to measure a variety of water quality parameters at three locations within the station. Grab samples obtained at the YSI sampling sites will be analyzed for alkalinity (using a portable Hach test kit) and sulfates (using a Hach DR700 Colorimeter). Take at least one upstream and one downstream photo of the station.

Select a Surber sampling site on a riffle where streamflow is about 4 inches deep or deeper but does not exceed 16 inches. Stream velocity is preferably greater than 1 fps but not in excess of about 3 fps. Predominate substrate size should be in the range of 25 to 150 mm. Embeddedness of the gravel and cobbles in silt and sand should be less than 30 percent (Milner and Oswood 1991).

Position sampler securely on stream bottom, parallel to water flow with the net downstream. Leave no gaps under edges of frame. Hold down with foot on corners of frame if necessary. (No Stikine Area samplers utilize a padded, foam rubber base.)

Carefully turn over and rub lightly all cobbles and stones down to large gravel size with hands to dislodge organisms. Examine each rock for organisms, larval, or pupal cases, and so forth that may be clinging to it before setting it outside of the Surber frame. Most algae scraped from rocks should also float into net unless very carefully examined. Bulky items such as small sticks should also be cleaned and examined carefully before discarding. Rocks that are half-in/half-out of the square-foot frame

should be included on an “every other rock” basis. Stir the remaining gravel and sand with hands to a depth of 2 to 4 inches (5 to 10 cm) for at least 30 seconds—longer if stirring is difficult or current is slower.

Pick up net by frame. Holding the frame in one hand, splash water on the outside of the net with the other to wash all insects and debris clinging to the inside of the net into the toe of the net (or the PVC cup if modified). Be careful not to splash water through the opening of the net (and subsequently add macros to your catch). A wide mouth sample bottle with CLEAN water may help rinse stubborn macros all the way down the net. Examine the inside of the net carefully before proceeding.

Transfer the sample to a pre-marked sample container. Stikine method: carefully unscrew PVC cup from net, checking for macros. Invert cup into Whirl-pak bag and slap end of cup with hand to empty most debris from cup. Take wide-mouth bottle and CLEAN stream water to wash residual sample down to smooth (unscreened) side of cup. Invert cup again into same sample bag. Take alcohol in wash bottle and squirt through the screened end of the cup, washing residual sample into sample bag. Add enough alcohol to cover sample in bag, and close by folding down over wire clasp. Only very sharp sticks should be removed (and examined) from the sample bag before closing. Contract lab will sort through other debris.

Collect specific sampling-site data, including:

- water depth using a staff;
- current velocity using a Price AA or Pygmy current meter,
- channel widths;
- comparison of substrate to distribution obtained across station, and
- other applicable notes.

Take at least one upstream photo of actual Surber sampler location.

Flag or otherwise mark sample location, including site i.d.

Verify (group review) complete data card before proceeding to next site/segment.

Sample I.D. and Metrics Analyses

Macroinvertebrate samples will be submitted for identification and calculation of a variety of metrics to the Environment and Natural Resources Institute at the University of Alaska at Anchorage. Metrics will include, at the least:

1. number of EPT individuals to total individual organisms;
2. number of EPT genera present;
3. percent Dominant Taxa;
4. Hilsenoff's family pollution index (FPI); and
5. Mangum's biotic condition index (BCI) (USDA, 1985).

In-situ water quality data collection using the YSI 3800 system will be performed according to company documentation. The mean of the three measurements for each parameter will be reported.

Alkalinity and sulfate analyses will be performed in a timely manner on each grab sample collected and according to Hach Company documentation.

Quality Assurance/Quality Control

Prior to any sampling during the analysis effort, the crew leader, who is experienced in macroinvertebrate sampling using a modified Surber net, demonstrates proper technique to all crew members involved in sampling.

Prior to sampling in any particular station, the crew leader explains to the crew the objectives for selecting and sampling within that station.

At each station, at least one of the five macroinvertebrate samples will be collected while one sampler is observed from start to finish by one observer (who otherwise is a crew member who actively samples). Discussion about procedures that the two might do differently is done immediately as situations arise. This process helps to minimize sampling differences and maintain continuity throughout the analysis effort.

Water quality sampling associated with macroinvertebrate sampling shall be performed according to good field practices given in standard texts such as Standard Methods (1989) and Stednick (1991). In-situ measurements will be obtained with equipment calibrated daily per manufacturer's instructions. Grab samples obtained for later analyses will be kept cool (<4 degrees C) from the time of collection until analyses are performed or will otherwise be preserved according to Standard Methods' (1989) procedures for that parameter. Sample handling logs will be kept to verify sampling procedures.

Together, the crew will review and verify data cards for completeness and accuracy before proceeding to next site/segment.

All calculations will be peer-reviewed or checked by verified, spreadsheet procedures for accuracy.

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Macroinvertebrate Sampling Equipment Needed

Modified Surber Net

12" square base and 18" high frame; net is 36" long with 280 micron mesh, except for vinyl bottom toe of net is adapted w/ PVC cup for quick transfer of sample to sample container Stikine uses 3 of these samplers, all constructed by Mangum's crew, except for PVC cup modifications in-house.

Insulated Gloves

Forearm and shoulder length; 3 pr

Whirl-pak Bags

To hold samples; write-on ability; enough to double bag all samples

Sharpie pens

To label sample bags; 3

M + Ethyl alcohol

Sample preservative in wash bottles, w/ extra in gallon container in vehicle

Wash Bottles

As above; total of 3

Wide Mouth Bottle

Without lid—helps to rinse cup/net

Clinometer

Stream gradient

Collapsible Staff

Stream depth and gradient

Current Meter

Stream velocity and discharge

Tape

Stream width, discharge

USGS discharge data cards

Velocity and discharge measurements

Hach alkalinity kit

Portable, on-site measurements

Sample bottles

Collect water samples for sulfate analyses near macro collection sites; one sample for each reach of interest; analyze in-house or at Montgomery Labs

Other WQ equipment

As deemed reasonable—DO, pH, conductivity, etc.

Pocket Scale

To calibrate eye for substrate measurements

Clipboards

Data collection

Pencils

Lots!

Data Forms

Blanks

Flagging and/or Flag-Pins

Use w/ Sharpies to mark sample location

Macroinvertebrate Sampling Data Forms

Figure M-1. Aquatic Macroinvertebrate Field Data Collection Form—Reach Description
Back (Graph paper for sketch) Front

1.5 pt.

=1.5 pt.

=1.5 pt.

Figure M-2. Aquatic Macroinvertebrate Sample Data Field Collection Form—Sample Sites
(Actually two forms per page; record additional notes on back if necessary.)

3.5 in.

1.51 in.

6.5 in.

Full-sized master forms, for reproduction use, are provided in pocket at the back of the appendices.

0.5 in.

Appendix 4.6
Basinwide Survey Protocol
for the
Region 10 Watershed Analysis

April 17, 1994

Region 10 Watershed Analysis

Stream surveys

Stream surveys describe the current condition of forest streams. Effects of different management practices can be compared to natural undisturbed states to assess current condition and to identify potential problems, i.e. limiting factors.

Survey for fish habitat is most effective on stream orders 1-3. Large streams are difficult to sample with snorkel and area estimation techniques. Smaller streams are most likely to be the first that are heavily effected by development activity.

Heterogeneity in bottom materials is desirable for good fish habitat. For example, large cobbles in riffle areas provide excellent aquatic insect habitat, whereas fine to coarse gravel, without excessive amounts of sand, silt, or fines provides good spawning materials for salmon. Excessive amounts of sand and/or silt characterize less-productive, degraded stream ecosystems (or geologic types rare in southeast).

The riparian zone plays an essential role in determining the quality of the aquatic habitat for fish. The most active area of exchange between land and aquatic systems is the area along the stream within two average tree lengths (according to one definition). Riparian vegetation provides shade, stabilizes stream banks, and provides cover. Riparian vegetation also directly controls the food chain of the stream ecosystem by providing organic detritus and insects for the stream organisms. It also provides woody debris to increase habitat diversity.

Stream Stratification

All streams are stratified into reaches for subgrouping large amounts of data collected from a particular watershed. This allows for more precise statistical analyses and facilitates data interpretation. Reaches are short sections of stream numbered sequentially from the start of each survey. Whenever feasible the survey should start at the downstream end and proceed upstream. Reaches are important for identification and location of specific habitat features and they allow the detection of variations within the stream.

Channel type

Channel types are derived from the the manual "A Channel type users guide for the Tongass National Forest, Southeast Alaska." This manual provides descriptions and parameters used in defining the channel types in Southeast. Each crew should have a copy of the photo key to channel types and a channel verification card to ensure correct identification of channel types during the habitat survey.

The following methods are suggested as ways to partition a stream into reaches: begin a new reach whenever 1) a tributary enters the stream and contributes > 10% to the main flow; 2) the channel type changes; 3) a potential/acting event occurs (fish barrier, road bridge/culvert, 4) you sample a tributary. Make every attempt to begin or stop a reach in a habitat unit that can be

identified both on the ground and on a topographic map. Record the criteria being used for a reach break in the remarks column.

In a systematic sample of units within a given habitat type, accurate measurements of unit characteristics are made using a metric tape or electronic distance measurers. The electronic distance measurers will give erroneous readings in stream sections with higher volume of noise, i.e. fastwater/rapids/cascades, etc. Common sense will dictate the correct use of the electronic distance measurers. If the recorder is making eyeball estimates for widths or lengths, then 30 percent of the widths and/or lengths must be measured to calibrate the estimated data. Note in remarks if estimation is being used for widths.

We are trying to snorkel 20 percent of the pools and 10 percent of the riffles/fastwater habitats. This means we need to sample every fifth pool and every tenth riffle or glide.

Selection of valid systematic samples for accurate measurements requires, independent random starts for the pool and for the fastwater habitats. Once the initial random start has been selected, all subsequent dives must be made at exactly the same interval. For example, suppose you are diving every 10th riffle. Start by randomly choosing a number, (pull a number out of a hat, guess, etc). If your random number is 4, then you will dive in riffle units 4, 14, 24, etc. If field work on the first day ended at riffle unit 54, then the first riffle unit for diving the next day would be 64. Units that will be snorkeled should be marked and identified. Place flagging at each end of the habitat unit boundary to be snorkeled and designate the habitat number, type, and the up- or down-stream end of the unit. If the unit boundary could be easily confused, flag all four corners of the unit. All side channel habitat types are also sampled, after choosing a random number to start. Side channels are very important fish habitat. The habitat unit on the main channel where the side channel is connected (enters and leaves) should be noted in the remarks. In large flood plains, it may not be obvious whether a channel is a major braid or a side channel. All habitat is surveyed in a basin-wide survey.

Data Collection

General Instructions:

1. All measurements will be in metric units.
2. All side channels will be considered a separate reach and all habitat types will be used in typing.
3. GIS standard watershed codes will be used
4. Fish species will be identified and recorded using the two Alpha characters of species.
5. Calibration ratios will be developed for each observer and the observer must remain the same through an entire reach.
6. Each habitat unit must have a unique number.

Office Phase

The objective of the office phase is to provide the field crews with an introduction to the stream system to be surveyed. Assembly and summarization of any data that has been previously collected for the basin will be used to tentatively stratify the stream system into stream order and stream reach. A reach is a relatively homogeneous section of stream that contains common characteristics.

Photo analysis and use of maps will allow identification of vegetative types in riparian and upslope areas, measurement of watershed area, and detection of road crossings (if present), access points, general location of geologic features, and tributary confluences. Any measurements should be confirmed by map wheel or scanner. Data base search should include fish species, ADF&G stream catalog number and data history, flow, water quality, macroinvertebrate, previous surveys, and historical land use.

Equipment needed

Field computer or waterproof data sheets

USGS quad maps and aerial photos when available

Office notes and comments

Field notebooks

Mechanical and wooden pencils (wood floats!), sharpies, or grease pencil

Flagging

100m and 30m tapes, electronic distance measurers, and spare batteries

Camera, film

Depth rod, thermometer, clinometer,

First-aid kit

Radio, rifle where needed

Dive suit (snorkel, mask, drysuit corks, and dive lights

Minnow traps, bait, buckets, measuring board, etc.

Surveyors must place permanent markers (metal or plastic tags) on mature trees at the end of reaches specifying date and reach number. Habitat survey data is entered directly onto a hand-held computer, usually a Hunter 16/80. The Datasheet program has been used to make the form used for data entry. To begin data entry type:

data habitat

The header for the habitat survey data will appear. All fields should be entered

1. Island: refers to geographic name of island
2. Stream: refers to map or common name
3. Date: is automatically entered for the present day (mmddyy)
4. Site: Main channel, tributary, or fork
5. Wtemp: Water temperature. Measure at least 3 times/day and at large tributaries
6. Quad map: USGS topographic maps containing the stream drainage
7. Atemp: Air temperature. Measure at least 2 times/day
8. Recorder: the person entering the data on the computer
9. Crew: All members present collecting data for the day
10. GPS (Y/N): Y if GPS coordinates are measured, N if no GPS measurements. Global positioning latitude and longitude for beginning and end of survey and major tributaries and landmarks
11. Aerial Pics (yr,flgt ln): aerial photos: FS flight line series and year for photos of stream drainage
12. Remarks: weather, water level or flow, special comments.

After all fields are entered on header page, proceed to data entry page.

Try to measure all parameters to identify channel types. 1) Channel width: bankfull width, 2) Gradient percent, 3) Incision depth, 4) Side slope length and angle

Data Entry fields:

CHL TYPE: Channel type as defined by Channel Type Field Key, Tongass National Forest, USDA

REACH NO.: Reach number changes as defined above. Use default previous key.

SC: Side channel, leave blank if not in side channel

HAB. NO: Habitat number each habitat unit gets a unique number. Use default countby one.

Habitat type: types and definitions of defined habitat types. The entire list of types will appear when you press Ctrl I (table 1 from Bryant).

Div/MT: Dive or minnow trap unit

MEA: measured length and width, don't estimate

Len: Length in meters--all units are measured (every 10th pool and riffle)

W1: Width 1, all units have one measured width

W2: Width 2, all fastwater types are measured at upstream and downstream ends

Depth Max: maximum depth in meters to nearest 5 cm

Depth Rfl crst: riffle crest depth=maximum depth at tail of pool or head of riffle in meters.

Riprn Veg: Rt bank/lft bank: riparian type (table 5__ripr list) and common species (table 5__veg list)

Cover percent: Cover is defined by table 2. Most dominant type is C1; then percent. C2 is subdominant, percent (in percent of total area). Example: a pool, 5x10m, with 1 log 0.5x10m lying on edge of water would be entered: LW 10. Substrate can be cover, especially CB and BD.

Substrate percent: Substrate is defined by table 3 (from channel type verification card). Dominant is S1 (alpha code), percent. S2 is subdominant (alpha code), percent

Wood Debris: Total number of pieces of large wood in each of six classes is entered in correct column.

Example: small=1 for one wood piece 1-3m long and .1-.9 diameter

Woody debris Classes: 4/94

Class	Length	Diameter	Class	Length	Diameter
small	1-3m	.1-.9	giant	>15m	>.9m
medium	3-7.6m	.1-.9	5	rootwad	<1m
large	7.6-15m	.1-.9	6	rootwad	>1m

Remarks: All pertinent comments, entry of tributaries, begin and end of side channels, photography points, landmarks, bridges or culverts, parallel road construction, migration barriers (i.e. falls, high velocity, etc.) weather, special sightings, etc.

Table 1. Key to habitat units used in the hierarchical habitat unit

MACRO_UNITS

- I. Water is slower and deeper than reach average; water surface gradient less than 1 percent.

POOL (PL) go to 1.

- II. Water is faster and shallower than reach average: water surface gradient is greater than or equal to 1 percent.

Fastwater (FW) go to 2.

- III. Secondary channel of main stream; channel with defined bank structure and separate from main channel-- not part of a braided main channel; water either flowing or standing, but source of water is main channel and not a tributary.¹ Original text of key: Secondary of main channel: water either flowing or standing, but source of water is main channel; not a tributary.

Side Channel go to 3.

MESO-UNITS

1. Pools:

- 1A. Pool associated with an obstruction along the bank; flow velocity decelerates throughout the length of the pool; water flow may diverge from the main axis of the channel.

Backwater Pool (PL-Bw) go to 4

- 1B. Pool often below a constriction or 'nick point'; flow rapid at entrance, decelerates in middle, and accelerates at exit; water often flows along the main axis of the stream;

Scour Pool (Sr) go to 5.

2. Fastwater

- 2A. Less than 20 percent of streambed breaks the surface at mean summer flows; gradient between 2 and 4 percent.

Riffle (Rf) go to 6.

- 2B. Flow slower and deeper than riffle; water surface smooth; gradient less than 2 percent.

Glide/Run (GR) go to 7.

- 2C. More than 20 percent of streambed breaks surface at mean summer flow; gradient greater than 4 percent.

Cascade (CS) go to 8.

3. Side Channels:

- 3A. Water flows throughout the channel; connected to stream at inlet and outlet.

Side Channel (SC) go to I or II (use main stream key; prefix habitat with SC).

- 3B. Flow discontinuous; water disconnected from main channel at either or both ends of the channel.

Off Channel (OC) go to 9.

MICRO-UNITS

4. Backwater Pool

- 4A. Pool Upstream of an obstruction partially or completely blocking flow; water flows over top of obstruction.

Dammed Pool (PL-dm).

- 4B. Pool downstream of a partial blocking obstacle that deflects flow, usually associated with the stream bank; flow direction either perpendicular or spiral with respect to stream thalweg.

Eddy Pool (PL-ed).

5. Scour Pool

- 5A. Usually downstream of a completely blocking obstacle; deepest part of pool located at head of pool; pool formed by water falling or flowing over the obstacle.

Plunge Pool (PL-pp).

- 5B. Channel constriction directing flow along stream bank; deepest part of pool located along or near bank; scour pool usually long and narrow.

Lateral Scour Pool (PL-lsc).

- 5C. Pool usually downstream of channel constriction concentrating flow to center of stream; deepest part of pool located in center of pool; scour generally along the axis of the thalweg.

Mid_Channel Scour Pool (PL-mcs).

6. Riffles

- 6A. Gradient between 2-4 percent; flow relatively uniform over unit; roughness coefficient >3 (roughness coefficient= water depth/substrate size).

Riffle (RF-rf).

- 6B. Gradient between 2-4 percent; roughness coefficient between 1 and 3; flow somewhat uneven; few cobbles may break water surface.

Cobble Riffle (RF-cb).

- 6C. Gradient between 2-4 percent; roughness coefficient <1; areas of high velocity and low velocity throughout unit; boulders (diameter >1m) may protrude surface.

Boulder Riffle (RF-bd).

7. Glides/Runs

- 7A. Gradient less than 2 percent; flows even across surface of unit; roughness >3.

Glide (GL-gl).

- 7B. Gradient less than 2 percent; flows somewhat uneven; surface unbroken by substrate at mean summer flows; roughness between 1-3.

Cobble Glide (GL-cb).

- 7C. Gradient less than 2 percent; flow moderately turbulent with pockets of low velocity behind boulders. Roughness <1.

Boulder Glide (GL-bd).

8. Cascades

- 8A. Gradient greater than 4 percent; water flows vertical with drop greater than 1/2 channel length
- 8B. Gradient greater than 4 percent; Usually high velocity over even surface such as bedrock or hard clay; roughness >3.

Chutes (CS-ch).

- 8C. Gradient greater than 4 percent; high velocity, turbulent flow with few areas of low velocity.

Rapids (CS-rp).

- 8D. Gradient greater than 4 percent; uneven flows; large substrate forms series of small steps and pools (pool length less than one channel width); roughness <1.

Falls (CS-fl)

Step-pool Cascade (CS-sp).

9. Off-channel

- 9A. Standing water in pools not connected to main channel.

Off-channel Pool (OC-pl).

- 9B. Channel connected at inlet of secondary channel, no outlet, either standing water or low velocity; gradient <2 percent.

Off-channel Run (OC-rn).

- 9C. Channel disconnected at inlet, connected at outlet, standing water or low velocity; gradient <1 percent.

Off_channel Slough (OC-sl).

Table 2—Cover components used in habitat surveys.

Macrounit	Mesounit	Description
Inorganic£	Bedrock (BR)	Rock substrate, either solid or fractured.
	Boulder (B)	Large rock greater than 256 millimeters in diameter.

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	Cobble (C)	Medium rock between 64-256 millimeters in diameter (hardball to basketball size).
	Gravel/pebble (GR)	Small rock 25-64 millimeters in diameter (up to hardball size).
	Undercut Bank (UC)	Water flowing or standing; undercut at least 1 m into the bank.
	Depth (D)	Water depth > 1 meter.
Organic	Rootwads (RW)	Base of tree and root structure.
	Log(s) (LW)	Tree boles or pieces greater than or equal to 30 centimeters in diameter and 2 meters long.
	Slash (SL)	Branches or pieces greater than 10 millimeters and less than 30 centimeters in diameter.
	Debris jams (DJ)	Large accumulations of organic material; 10 or more logs.
	Overhanging vegetation (OV)	plants growing on bank (includes logs not touching water surface)
	Aquatic vegetation (AV)	plants growing in the water
Fabricated Structures (M-manmade)		
	Gabions	Rock-filled wire baskets.
	Log structures	Dams, deflectors used to control flow direction or retain gravel.
	Road crossings	Bridges, culverts.
	Wood debris	Artificially placed trees.

Table 3. Substrate categories and descriptions.

Substrate (SU)	Description
----------------	-------------

Bedrock (BR)	Single piece or fractured rock (>1m)
Boulder (B)	Separate rock greater than 256 millimeters in diameter.
Large Rubble (R)	large rock between 125_256mm in diameter
Cobble (C)	Medium rock between 64-125 millimeters in diameter.
Coarse Gravel	large gravel mixture between 25-64 millimeters in diameter.
Fine Gravel (FG)	small gravel mixture between 2_25 millimeters in diameter
Sand (S)	Fine rock less than 2 millimeters in diameter.
Fines (F)	Silt, clay (mud) less than 1mm diameter.
Fine organic	Needles, decomposed leaves and wood particulate matter.

Table 4--Fish species.

Fish species codes:

1	CO	'Coho salmon
2	DV	'Dolly Varden
3	SH	'Steelhead
4	CT	'Cutthroat trout
5	SE	'Sockeye salmon

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6	SB	'Stickleback
7	KO	'Kokanee salmon
8	SC	'Sculpin
9	CK	'Chinook salmon
10	PK	'Pink salmon
11	CM	'Chum salmon
12	AD	'Anadromous Dolly Varden
13	NF	'No Fish
14	UK	'Unknown

Table 5. Riparian vegetation and species list.

Ripr list: Riparian vegetation		Veg list: common riparian species	
OG	Old growth	S	Sitka Spruce
SG	Second growth	H	Western hemlock
CC	Clear cut	A	Alder
BP	Beaver pond	C	Cedar (red or yellow)
M	Muskeg	B	Blueberry
LS	Landslide	D	Devil's club
T	Tidal	Q	Skunk cabbage
		Y	Salmonberry
		K	Stink currant
		G	Grass

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Region 10 Watershed Analysis

Appendix 4.7
Road Condition Survey Protocol
for the
Region 10 Watershed Analysis

Julianne E. Thompson
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Stikine Area
Tongass National Forest
June 10, 1994

Introduction

This plan proposes a standardized, repeatable method of evaluating road condition, sediment source and transport risks, stream-crossing structure operations, and fish passage.

Objectives

Evaluate road prism condition:

- Extent of active erosion on the travelway, cutslopes, fillslopes, and drainage system
- Extent of road subsidence and associated road drainage impairment
- Extent of impaired road drainage (blocked ditches and impaired or missing cross-drains)

Evaluate stream-crossing operations and condition:

- Numbers of impaired and functional stream crossings
- Extent of operational impairment (bedload deposition, erosion, failures)
- Sediment input risk
- Maintenance risk and needs

Evaluate rock quarry condition:

- Sediment source risk
- Sediment transport risk

Verify accuracy of stream inventory:

- Numbers of mapped and unmapped streams

Identify water quality protection needs:

- Site-specific recommendations, where applicable, to address water quality protection objectives and restoration needs.

Evaluate fish passage on Class I and II streams:

- Incorporate Petersburg Ranger District's fish passage survey program results.

Procedures

Stikine Area will survey all system and nonsystem (temporary) roads in Kadake watershed. The survey will begin with a randomly selected fifty-percent sample to ensure representative results are available

within the watershed analysis timeframe. Field forms with instructions and definitions are at the end of this appendix; originals for reproduction are in a pocket at the back of the appendices.

Road survey personnel will complete the road condition monitoring form (6/10/94 version) in the field for each system and nonsystem road.

Fisheries personnel will complete a fish passage survey on all Class I and II streams. Fish passage survey includes most of the observations contained on the drainage structure operations/maintenance form (7/23/94 version). Fisheries personnel tag each surveyed stream with a unique milepost identifier. Road survey personnel follow and complete the drainage structure form on all untagged mapped streams (Class III streams) as well as any other unmapped streams with bankfull width of at least three feet.

Road survey and fish passage survey data are maintained on Lotus database.

Road Condition Survey Equipment Needed

Road condition survey requires the following supplies:

Truck

With accurate odometer

Hip chain

For impassable and temporary roads

Road map

Can plot with streams on GIS

GIS Stream Inventory Plot

Showing watershed minor codes, AHMU class and channel type

Tally meter

For tallying observations

Clinometer

For measuring culvert gradient—check for accuracy before you head out into the field

Folding staff

With tenth foot rule for measuring culvert diameter, also helpful for culvert gradients

Field forms

On waterproof paper

Tape measure

100 foot—for measuring stream width and structure length

Optional supplies

Include a camera for photographing maintenance needs and aerial photos.

Road Condition Survey Field Forms

Figure D-1. Drainage Structure Operations/Maintenance Form.

1.5 pt.
=1.5 pt.
=1.5 pt.
4.4 in.
1.25 in.
.5 in.
=6.5 in.

Full-sized master forms, for reproduction use, are provided in pocket at the back of the appendices.

Road Condition Survey Field Forms

Page 1 of 3, Survey Form

Figure D-2. Road Condition Survey Form.

1.51 in. 3.5 in.
.4 in.
=6.5 in.

Page 2 of 3, instructions

1.51 in. 3.5 in.
.4 in.
=6.5 in.

Page 3 of 3, continuation page

1.51 in. 3.5 in.
.4 in.
=6.5 in.
0.5 in.

Appendix 4.8
Hillslope Traverse Procedure
for the
Region 10 Watershed Analysis

Hillslope Drainage Frequency Data Collection Procedures

Region 10 Watershed Analysis

Purpose

This process determines the frequency, channel morphology characteristics, and streamflow conditions for unmapped mountainslope drainages on frequently dissected, deeply incised mountainslopes (31 landform unit), and frequently dissected, shallowly incised mountainslopes (32 landform unit). The landforms investigated for this data directly abutted a valley bottom channel type (C3) with a well-developed floodplain.

Site selection

1. Determine the candidate mountainslope(s) by reconnaissance of channel-type mapped aerial photos or direct field reconnaissance.
2. Establish traverse elevation at a line bisecting the mid-slope position (i.e. above the footslope and below the shoulder of the mountainslope) of the candidate mountainslope. This insures encountering the greatest degree of channel formation of the drainages.
3. Determine start and termination points by easily found landmarks if possible.

Data

1. Determine type of drainage: v-notch, rill, swale, or other.

V-notch = well-defined, steep sideslopes, well-defined channel with a classic v-shaped cross-sectional profile and large substrate (rubble or larger) channel may be rectangular also.

Rill = shallow incision, gradual slope to sideslopes, narrow, rectangular channel, usually small substrate (rubble or smaller)

Swale = poorly defined drainage, normally a discernible depression in the cross slope profile, presence of hydrophytic plant species (skunk cabbage), absence of a definable channel.

**** Classifying drainages is optional.**

2. Sideslope Length: measure length of sideslope from crest of slope to the top of bankfull channel, use hip chain, rangefinder, or tape. If no discernible break between slope and channel, measure to the lowest point.
3. Sideslope gradient: measure slope gradient in degrees (actually the angle of the sideslope from a horizontal datum); use clinometer and stadia rod.

**** Both sideslopes and corresponding angles can be measured and then an average value can be calculated; however, only measurements on one sideslope are required.**

4. Channel width: measure bankfull channel width, use tape or stadia rod, record measurement to the nearest 0.1 meters.
5. Channel depth: measure from a bankfull datum line, use a stadia rod to measure depth at lowest point for channels under 2 m., calculate an average value (based on 3 measurements) for channels greater than 2 m.
6. Channel gradient: measure along channel bed using stadia rod and clinometer. Distance for the gradient measurement should be at least 10 m. but depends upon vegetation conditions and observable distances.
7. Present flow conditions: note state of flow in channel, i.e. continuous streamflow, intermittent flow, or dry channel.
8. Substrate: ocular estimate of the mean substrate size class, employing the same classes as used in the Channel Typing Verification Procedures.
9. Bearing: record compass bearing of channel along the downstream aspect, optional, may help in tracking position across the mountainslope.

Miscellaneous points

1. Check altitude continuously during the traverse to insure maintaining proper position on slope.
2. Equipment list:
 - Clinometer
 - Altimeter
 - Stadia rod
 - Tape
 - Hip chain
 - Rangefinder
3. Record data to the nearest 0.1 meter for channel measurements and sideslope measurements.

Appendix 4.9
Fish Passage/Culvert Monitoring Procedure
for the
Region 10 Watershed Analysis

October 1992

Region 10 Watershed Analysis

Introduction

There is a demonstrated need for a systematic approach to evaluate the operational effectiveness of culverts and bridges on critical stream crossings. Critical crossings have been identified in the Kelp Bay and Southeast Chichagof project areas. These sites will be monitored for meeting the design functions, fish passage, and water quality objectives established by R10 Soil and Water Conservation Handbook and the State of Alaska Water Quality Criteria.

Objective

The primary objective of road drainage structure monitoring is to evaluate critical crossing structures for the ability to pass anadromous fish and the designed high flow. The secondary objective is to evaluate the need for maintenance at the critical crossings structures and at all culverts and bridges in the monitored road segment.

Parameters Selected

Specific elements of hydraulic function, fish passage, and channel conditions will be evaluated at each monitoring site.

1. **Condition survey of structure.** The overall condition of the culvert or bridge will be visually evaluated for passing the design flow. A condition rating will be used to rate the present capacity. The inlet and outlet of the structure will be evaluated for blockage that is the result of debris or sediment. Maintenance needs will also be noted.
2. **Hydraulic function and Fish passage.** A brief examination of the channel above the structure is necessary to determine if the structure allows for adult and/or juvenile anadromous fish migration. However, a brief visual examination may not be definitive, depending on time of year and flow conditions.

Any blockage or constriction in the pipe may increase flow velocity or create a gradient barrier to adult and juvenile passage. The height of the vertical drop at the pipe outlet is crucial. Heights that are not in proper proportion to the plunge pool will restrict adult passage. Any vertical drop will restrict juveniles. Culvert gradient is also critical in ensuring fish passage. A culvert not properly graded will create a flow velocity barrier. Large, low-angle pipes that do not retain stream bed material also inhibit juvenile passage.

Flow velocity through the culvert will be measured and compared to anadromous juvenile swimming capability to determine if the velocity is excessive for fish passage.

3. **Channel Stability Assessment.** Stream channel processes of aggradation and degradation are important to the long-term stability and maintenance needs of the structure. A

visual reconnaissance of the upstream channel conditions and a rating system of high, moderate, and low for bedload deposition and channel scour will be part of the monitoring procedure.

4. **Maintenance Risk Assessment.** A rating system based on the deployment and stability of large woody debris above the structure will be part of the monitoring process. The presence of beaver activity will also be noted.

These factors will be evaluated to determine the overall maintenance risk associated with the structure. Any immediate maintenance needs will also be noted. A date for maintenance work will be set and accomplishment will be evaluated at subsequent monitoring efforts. Results will indicate how effective actual maintenance work is in protecting water quality in roaded watersheds on the Chatham Area.

Procedures

The Chatham Area Ranger Districts will be responsible for monitoring the roads under their jurisdiction. All permanent specified roads on the District will be inventoried. Station numbers from the TIS system should be used to

identify culvert and bridge locations. In addition, a global positioning system (GPS) should be used to locate and identify each evaluated culvert for insertion into a GIS database.

A road culvert inventory should begin at the selected road segment terminus or junction with another specified road. A hip chain for measuring stations or the GPS should be used starting at this point. A tally sheet with cataloging information will be used to record culvert position, size, inlet and outlet condition for all culverts that function as road cross drains or as ditch relief. All bridges or culverts that require fish passage will be tallied and evaluated using the Critical Crossing Site data sheet—usually this will be culverts 36 inches in diameter or larger.

Quality Control

Field crews will receive adequate training in measurement techniques by the Area Hydrologist to ensure uniform measurement precision. A standardized tally sheet and Critical Crossing Site data card will be used. Data will be stored in the Chatham Area's Oracle database. Quality control for data entry will be the responsibility of the District or SO Watershed staff. Maintenance needs will be forwarded to the SO Engineering Department.

Frequency

In a given year, 25 percent of the District road systems will be evaluated. This equates to 81 miles on the Sitka District and 50 miles on the Hoonah District. The total road systems on the Juneau and Yakutat Districts should be evaluated in one year.

Data Analysis, Evaluation, and Interpretations

This data will provide a comprehensive inventory on all critical culverts and bridges on the ranger district. Maintenance needs will be identified and can be summarized for each specified road. Total number of culvert and bridges, location of dysfunctional fish passage culverts, and maintenance needs are data that will be generated by this inventory.

Cost Estimate

Salary: \$3,900 per year

Travel: \$2,250 per year

GPS: \$3,000

Data Analysis: \$1,650 per year

Region 10 Watershed Analysis

Appendix 5
Geographic Information System
Evaluation

Use. Estimates of landslide and surface erosion potential and the occurrence of wetlands and riparian areas were all based on information, either directly or indirectly, found within this coverage. This coverage was used extensively in describing watershed attributes and provided the majority of mapped information.

Shortcomings. Accuracy of any large GIS coverage with very spatially specific polygons is often a problem. Limited field verification of this coverage has shown it to be relatively accurate for most features. Statistically, it may lack rigor, but for this initial analytical effort, it served us well.

Recommendations. This coverage, like most large coverages on the Tongass National Forest, needs validation, consistent updates, quality control, and corporate data management. These will be discussed later.

Harvest Units

All past and potential harvesting activity was available through the harvest unit covers for each of the administrative areas (Areas). These databases are updated annually and contain such information as harvest and yarding date, unit size, and, in some cases, species. The maintenance of this coverage is the responsibility of the Areas. The information for this cover is obtained from the harvest unit cards which describe all harvest unit activity. This information is then digitized into the system and information about the unit is added.

Use. This coverage was used to ascertain the level and intensity of harvest activity in the watershed. Distances from streams to adjacent harvest areas can also be measured. From this coverage, remaining timberlands can be estimated, and it indirectly provides the data needed to calculate long-term timber harvest potential. Since harvest activity is scrutinized quite closely by many public interest groups, this coverage is frequently mapped and updated.

Shortcomings. This is a very large and complex coverage and suffers with the same problems found in other large databases, including inaccuracies with spatial locations. These will be discussed later.

Recommendations. The harvest units coverage is one of the most valuable and scrutinized coverages in the Region. Since there are so many laws and regulations governing harvest activity (e.g., buffers, adjacency, size), it is imperative that this coverage be accurately digitized and attributed. It is probably the most easily digitized and verified coverage for the Tongass. The labeling of polygons is the biggest problem facing the harvest units coverage (besides consistent updating). Each area has its own list of items to use in describing the units, thus making it very difficult to join the coverages of all three areas. In order for there to be consistency, there must be direction from the Regional Office that not only is implemented, but that meets the needs of the area planners and resource specialists.

Streams

The forestwide stream coverage was used to show the streams and stream types located in the watersheds. This coverage contains thousands of miles of streams and many stream attributes. Some of these are stream class, channel type, process group, width, order, watershed, and many others. In addition to this coverage, several areas enhanced their stream inventory on the watersheds through aerial photography analysis and ground surveying.

Use. This coverage was extensively used in the watershed analysis process. Derived from this coverage are fish production models and flow values. Fish habitat quality and the ability of the stream to recover from disturbance (e.g., a large sediment release) can all be derived from information found within this coverage. This coverage was included on most watershed maps in order to determine proximity to harvest units, roads, and general location and shape of channel.

Shortcomings. This coverage lacks completeness. It is estimated, and in several cases known, that as many as 30 percent of the streams in a watershed may not be included in the streams coverage. This represents a significant problem for any planning or analytical activity, including watershed analysis.

Recommendations. Considering the importance of this coverage to many aspects of forest management, it should be updated to the current level of inventory knowledge. In cases where ground truthing is not possible or too expensive, analytical techniques could be used to estimate missing stream networks. Using DEMs (as described above), flow models can be used to locate highly probable stream locales. Overlaying the existing stream coverage on this will show areas where non-inventoried streams might exist. These can then be used to enhance the existing coverage and improve many other resource inventory estimates.

Transportation Networks

The location of existing and proposed roads and utility corridors was obtained through the forestwide transportation network coverage. This was used to estimate existing and potential ground disturbing and sediment producing activities that may influence water quality. This coverage is updated annually and includes many attributes concerning the road system. These include road classification, proposed construction date, maintenance level, closure, etc.

Use. The level of road construction (and estimates of probable sedimentation) are based on this coverage. Future roading activity and utility corridor development estimates are also available from this coverage. This coverage was used primarily to determine the proximity of roads to streams and the number of stream crossings etc. It was also an important coverage in assisting the watershed analysis field crews in the planning and logistics of their work.

Shortcomings. Lack of timely updates and inaccuracy of the road network arcs are the biggest problems with this coverage. In many cases, the road was added to the coverage prior to actual construction. During construction, some unforeseen event caused the road to be moved from the original course. In many cases, this change was not made in the network coverage. Also, the category of the road and current status (closed, open, etc.) is often incorrect.

Recommendations. Consistent and timely updates and verification are essential. Roads, like harvest units, should be one of the easier coverages to keep up-to-date and spatially accurate since they are often well-known by field personnel and easily seen in aerial photography.

Vegetation Type

The forestwide timber type (TIMTYP) map was used as one method to determine the vegetative composition of the watersheds. This coverage was developed in the mid-1980s and is currently undergoing extensive review and updating. Included in this coverage are stand type, species, merchantable volume, volume class, nonforest classifications, and stand productivity.

Use. The primary use was to describe and show the existing level of forest vegetation in each watershed.

Shortcomings. The problems with this coverage are currently being addressed. Studies conducted since the timber type coverage was created have shown a high level of inaccuracy for certain classes of volume and species. However, for the most part, this coverage does provide a very good estimate on the forested and nonforested areas of the Tongass.

Recommendations. Continue to address the inaccuracies and use this coverage only for those attributes for which it can accurately predict. This coverage is probably suitable for watershed analysis, as watershed analysis exists today.

A project currently underway should provide information to future watershed analyses. This study, titled "Stream Buffer Stability and Consequences of Blowdown in Southeast Alaska" is a cooperative effort involving the Forest Service and the Alaska Department of Environmental Conservation and is funded in part by the U.S. Environmental Protection Agency.

Monitoring needs and concerns identified by the AWATs

Chatham Area

Currently, the sediment transfer hazard classification system only considers slides that are greater than 0.5 acres. The Chatham AWAT believes that the small (less than 0.5 acres) slumps observed in the Game Creek watershed should be monitored to determine if they represent a significant sediment source and if they should be included in the sediment transfer hazard model. It was suggested that Unit 135 and other units lying on frequently dissected, shallowly incised mountainslopes be monitored for sediment production over five to ten years as hillslope root strength decreases to its minimum before rebuilding.

It is worth noting that all of the AWATs expressed concern over the methods used to determine nonpoint and point sources of sediment in the sediment transfer hazard model. In addition to the study proposed above, more specific information (such as that collected in road condition and drainage structure monitoring and from landslide surveys) could increase the reliability of results obtained from the model. Also, the ratio of Class I and Class II streams to Class III streams as an indicator of sediment movement and deposition hazard may not be accurate since many Class III (or smaller) streams may not be mapped.

Effectiveness of low-angle road dips as stream-crossing structures should be monitored. Such dips should be installed on stream crossings for roads crossing active alluvial fans in the Game Creek watershed. The dips would replace culverts that are currently in place and which are not functioning adequately. The hypothesis is that the dips pose less risk of sediment delivery to the channel (because they in essence cannot fail) compared to stream crossings using culverts.

Ketchikan Area

Sediment delivered to streams from road cuts should be monitored. A relatively large amount of steep cut and fill slopes exist on the mainline road in the Old Franks Creek watershed. These slopes are too steep to revegetate, as grass seed will not "take." Many of these slopes are adjacent to stream crossings. The amount of sediment entering the streams and the impact of the sediment is unknown. A monitoring program should determine impacts and if mitigation (e.g. rip-rap) is needed.

The effects of buffer strip blowdown should be monitored. Prescriptions for timber harvest units varied on Class III streams from no buffer to leaving a substantial buffer. Blowdown was occurring to varying degrees. Such blowdown can have a negative effect

if root wads are pulled up adjacent to the stream, if loss of root strength results in mass waste, and if large wood recruitment over time is disrupted. However, blowdown into the stream could have a positive effect by providing a source of large woody debris. Monitoring could determine the degree to which such buffer areas are blowing down and the effects, both positive and negative, of any blowdown on the streams.

Stikine Area

The value of monitoring macroinvertebrate populations should be determined. The usefulness of macroinvertebrate sampling as a monitoring tool, relative to other data that was collected, is questioned. Variation is so high that useful conclusions are elusive without extensive sampling investment. Effectiveness monitoring of the macroinvertebrate protocol will be useful in determining future watershed analysis design.

The scale of blowdown monitoring should be expanded. Monitoring of blowdown should include sampling and measuring site-specific and landscape-level factors that contribute to blowdown. This interest arose from the observation that little blowdown occurred in the Kadake watershed, including buffers and unit boundaries that are 15 to 20 years old. Other watersheds, including the Game Creek watershed on the Chatham Area, have experienced significant blowdown in relatively recent buffers and unit boundaries. This suggests that monitoring buffer and unit boundary stability and the factors contributing to the incidence of blowdown should be done as soon as possible, to provide input to future timber sale planning. Note that this monitoring need corresponds to Phase III of the Buffer Stability and Consequences of Blowdown project discussed above.

Additional riffle stability index data on multiple channel types is needed to establish the means and ranges of variation within and between channel types.

The USGS step-backwater flow analysis should be repeated and increased steelhead redd counts should be conducted.

Region 10 Watershed Analysis